INSTRUCTION MANUAL

EG&G INC.

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AUTOMATIC PICOAMMETER

MODEL ME - 920

Including Option 02

MP MASTER
MA28899

LAS VEGAS OPERATIONS

INSTRUCTION MANUAL

AUTOMATIC PICOAMMETER

Model ME-920

Option 02 *

* See Page 7

SYMBOLS & ABBREVIATIONS

Symbol	Meaning
milli (m)	10^{-3}
micro (μ)	10^{-6}
nano (n)	10^{-9}
pico (p)	10^{-12}
fempto (f)	10^{-15}
Kilo (K)	10^{3}
Mega (M)	10^{6}
Giga (G)	10^{9}
Tera (T)	10^{12}
v	Volts
millivolt (mv)	10^{-3} Volt
microvolt (μv)	10^{-6} Volt
amp (a)	Ampere
milliamp (ma)	10^{-3} Ampere
microamp (μa)	10^{-6} Ampere
nanoamp (na)	10^{-9} Ampere
picoamp (pa)	10^{-12} Ampere
femptoamp (fa)	10^{-15} Ampere
sec	Seconds
milliseconds (ms)	10^{-3} Second
microseconds (μs)	10^{-6} Second
nanosecond (ns)	10^{-9} Second
Hz	Cycles Per Second
KHz	10^{3} Cycles Per Second
MHz	10^{6} Cycles Per Second
Ω	Ohms
KΩ	10^{3} Ohms

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Symbols & Abbreviations (Continued)

Symbol	Meaning
MΩ	10^6 Ohms
GΩ	10^9 Ohms
~	Approximately
db	Decibels
°C	Degrees Centigrade
F.S.	Full Scale
O.R.	Over Range
Σ_j	Summing Junction
pot	Potentiometer
F-R DCU	Forward-Reverse Decimal Counting Unit
ADC	Analog-to-Digital Converter
DAC	Digital-to-Analog Converter
MSD	Most Significant Digit
LSD	Least Significant Digit
BCD	Binary Coded Decimal
NMR	Normal Mode Noise Rejection
CMR	Common Mode Noise Rejection
MOS FET	Metal Oxide on Silicon Field Effect Transistor
P.C.	Printed Circuit
INC	Increase
DEC	Decrease
AUTO	Automatic
MAN	Manual
REM	Remote
RMS	Root-Mean-Square

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SECTION I - GENERAL INFORMATION

1.1 General Description

The EG&G Model ME-920 Automatic Picoammeter is of all solid-state construction and has the capability of automatically measuring positive or negative direct current from ±10 ma to ±10 picoamps full scale. The measured current is displayed on a 3-3/4", 1% meter. In addition, polarity and range exponent information is displayed with neon glow tubes. Range changing is accomplished either automatically or manually in ten inclusive decade steps ($\pm 10^{-2}$ amps to $\pm 10^{-11}$ amps). Polarity determination is automatic.

Outputs are provided for mono-polar and bi-polar analog recording, and digital recording of polarity and range exponent. All front panel controls, with exception of zeroing, may be remotely programmed.

1.2 Display Format

The display consists of three neon numeric glow tubes and a 3-3/4", 1% meter movement (Figure I) arranged left to right to display polarity, amperes, and range multiplier exponent.

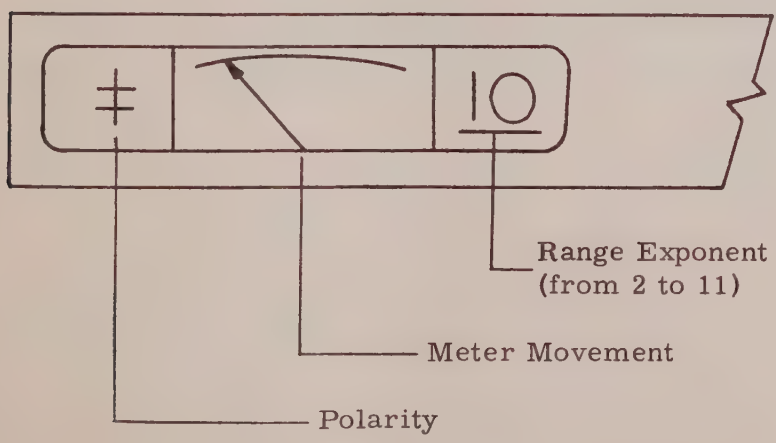


FIGURE I

NOTE: Range display is the negative exponent of a decade multiplier, thus for an input current of $+1 \times 10^{-6}$ amps, the exponent would be displayed as 6; for $-.75 \times 10^{-11}$, the exponent display would be 11, etc.

1.3 Specifications

1.3.1 Ranges

Full scale ranges are in ten (10) inclusive decade steps from 10^{-2} amperes to 10^{-11} amperes full scale.

1.3.2 Polarity

Positive polarity is conventional current into the center conductor of the BNC input connector. Polarity selection is automatic with a response time of less than 250ms for ±5% full scale input step function. Polarity is displayed on the front panel by a neon glow tube. A digital output is provided for remote polarity monitoring.

1.3.3 Accuracy

Accuracy is specified as the worst-case errors accumulated when calibrated according to the procedure outlined in this Instruction Manual. These specifications are valid at 25°C ±1°C, 50% relative humidity for one month after calibration.

Accuracy does not include effects of input voltage offset, current offsets. The temperature coefficient for each range is given in the following section.

TABLE I

Range	Accuracy	Note
10^{-2} thru 10^{-5}	±.05% of Reading ±.1% F.S.	Fixed ranges, not adjustable
10^{-6}	±.2% of Reading ±.1% F.S.	Ranges adjustable to stated accuracy under stated conditions with EG&G Model TF-601 Calibrator
10^{-7}	±.35% of Reading ±.1% F.S.	
10^{-8}	±.5% of Reading ±.1% F.S.	
10^{-9}	±.75% of Reading ±.1% F.S.	
10^{-10}	±1.0% of Reading ±.1% F.S.	
10^{-11}	±1.25% of Reading ±.1% F.S.	

Ranging accuracy between adjacent ranges is plus and minus the difference of the absolute value of percent of reading of the two ranges, ±.1% F.S. For example, ranging accuracy between 10^{-7} and 10^{-8} is

$$\pm\,(\,|\pm.5\%| - |\pm.35\%|\,)\ \pm.1\%\ \text{F.S.}$$
$$= \pm.15\%\ \text{of Reading}\ \pm.1\%\ \text{F.S.}$$

1.3.3.1 Temperature Coefficient

Range	Tempco - PPM/°C
10^{-2} thru 10^{-5}	±100
10^{-6} thru 10^{-8}	±300
10^{-9}	±700
10^{-10}	±800
10^{-11}	±1000

1.3.4 Range Control/Display

Range control is automatic or manual, selectable at the front panel. Clock rate of auto ranging is approximately 500 ms per range. Automatic sensitivity decrease and increase thresholds

are nominally 100% full scale and 8% full scale, respectively. Thresholds are internally adjustable from >110% - 90% and 9.5% - 5%, respectively.

Manual ranging is controlled by momentary contact front panel pushbuttons INC and DEC, i.e., increase and decrease sensitivity. Each depression of the pushbutton changes sensitivity by one decade.

Range display is by means of two numeric neon glow tubes. The number displayed is the negative exponent of the power of ten multiplier, i.e., display of 11 indicates a multiplier of 10^{-11}.

1.3.5 Programming

Programming is single point control to remote common line brought out with program lines. Programming is possible only when instrument is switched to REM function.

Programming is a switch closure to remote common, or saturated NPN transistor.

1.3.6 Input Resistance

Maximum voltage drop for full-scale currents on any range is 1 mv. This results in maximum input resistance of .1 ohms on 10^{-2} amp range, increasing by decades to 100 megohms on the 10^{-11} amp range.

1.3.7 Input Voltage Offset

Temperature Effect	Less than $\pm$10 mv drift from 5°C to 50°C
Drift	10 mv maximum in 10 hours after 10-minute warm-up
Adjustment	To within 500 μv of zero with front panel control

NOTE: 10 mv of offset results in 0.1% of instrument offset on 10^{-2} thru 10^{-7} ranges and 1% instrument offset on 10^{-8} thru 10^{-11}.

1.3.8 Input Current Offset

Temperature Effect	Less than $\pm 10^{-13}$ amps drift from 5°C to 50°C
Steady State	3×10^{-13} amps maximum 5×10^{-14} amps typical

1.3.9 Bandwidth

Bandwidth is measured at the bi-polar analog output provided on the ACCESSORY connector.

	Bandwidth in Hz with Shunt Capacitive Loading	
Range	0 pf	5000 pf
10^{-11}	1	.3
10^{-10}	5	2
10^{-9}	50	20
10^{-8}	500	200
10^{-7}	1K	500
10^{-6}	1K	1K
10^{-5}	2K	2K
10^{-4}	10K	10K
10^{-3}	10K	10K
10^{-2}	10K	10K

1.3.10 Digital Outputs

1.3.10.1 Standard Digital Data Outputs

Polarity: Single line binary, diode coupled, 2 ma sink maximum.
Negative polarity is >+6v
Positive polarity is <+1v

1.3.10.2 Option 01 - Digital Range Output

Levels: Positive zone positive true
+5.5 volts or greater is logical "0"
+1 volt or less is logical "1"

Range	BDC Lines			
	1	2	4	8
10^{-2}	0	0	0	0
10^{-3}	1	0	0	0
10^{-4}	0	1	0	0
10^{-5}	1	1	0	0
10^{-6}	0	0	1	0
10^{-7}	1	0	1	0
10^{-8}	0	1	1	0
10^{-9}	1	1	1	0
10^{-10}	0	0	0	1
10^{-11}	1	0	0	1

Table IV
Range Truth Table

1.3.11 Output Connections

Connector J-4 PRINTER

Pin	Function		Pin	Function
1			13	
2			14	
3			15	
4			16	
5	Common		17	
6			18	
7	Polarity + = <1v - =>6v		19	
8			20	
9	1		21	
10	2	Range	22	
11	4		23	
12	8		24	

Connector J-3 ACCESSORY

Pin	Function	Pin	Function
1	Remote Manual Increase	13	
2	Remote Manual Decrease	14	
3	Remote Manual	15	
4	Remote Common	16	
5	Analog Range Output*	17	
6	Bipolar Analog ±10 v F.S.	18	
7	Monopolar Analog +10 v F.S.	19	
8	Analog Common	20	
9		21	
10		22	+15 v DC
11		23	-15 v DC
12		24	Common

1.3.12 Noise Rejection

A. Common Mode Noise

The input connector to the ME-920 is isolated from the chassis with approximately 1200 pf in parallel with 100 megohms. A maximum difference in potential of ±150 v DC or 115 v RMS, 60 Hz can be sustained between the input connector and chassis with no change in specifications.

1.3.13 Environment

Temperature	5°C - 50°C
Humidity	0 - 50% relative humidity

* 0 to +9.99 volts in 1.11 volt steps

0 = 10^{-11} Range, +9.99 = 10^{-2} Range

Accuracy: ±1% of Range, ±30mv

5ma maximum, low Z source, short circuit proof

SECTION II -- INSTALLATION

2.1 Incoming Inspection

This instrument was inspected both mechanically and electrically before shipment. The instrument should be in operating condition upon receipt; however, the top cover should be removed and the instrument inspected for damage prior to applying power. If there is damage or a deficiency, see the Warranty on the inside of the front cover. There should also be packaged with the instrument the following items: Instruction Manual, a P.C. Card Extender, and two (2) mating connectors for Printer and Accessory outputs (Amphenol 57-30240).

2.2 Installation and Checkout

The instrument can be operated as a bench-top unit or rack-mounted. The ME-920 can be rack-mounted by utilizing rack-mounting ears purchased from EG&G or by installing chassis track rails, Zero Manufacturing Company Type AT-2RN or AT-2XN.

Access for mounting the rack ears or chassis tracks is accomplished by snapping off the rear end caps (see Figure II) and sliding the handle cover plate off. The rack mount ears are mounted to replace the front end caps. The main frame side panels have been drilled and tapped for the chassis track rails.

IMPORTANT

On the most sensitive ranges, effects of mechanical vibration and input cable movement will generate noise currents. In extreme cases, noise will cause uncertainty in automatic range determination. Care should be taken to minimize flexing of input cable and all types of vibration in general.

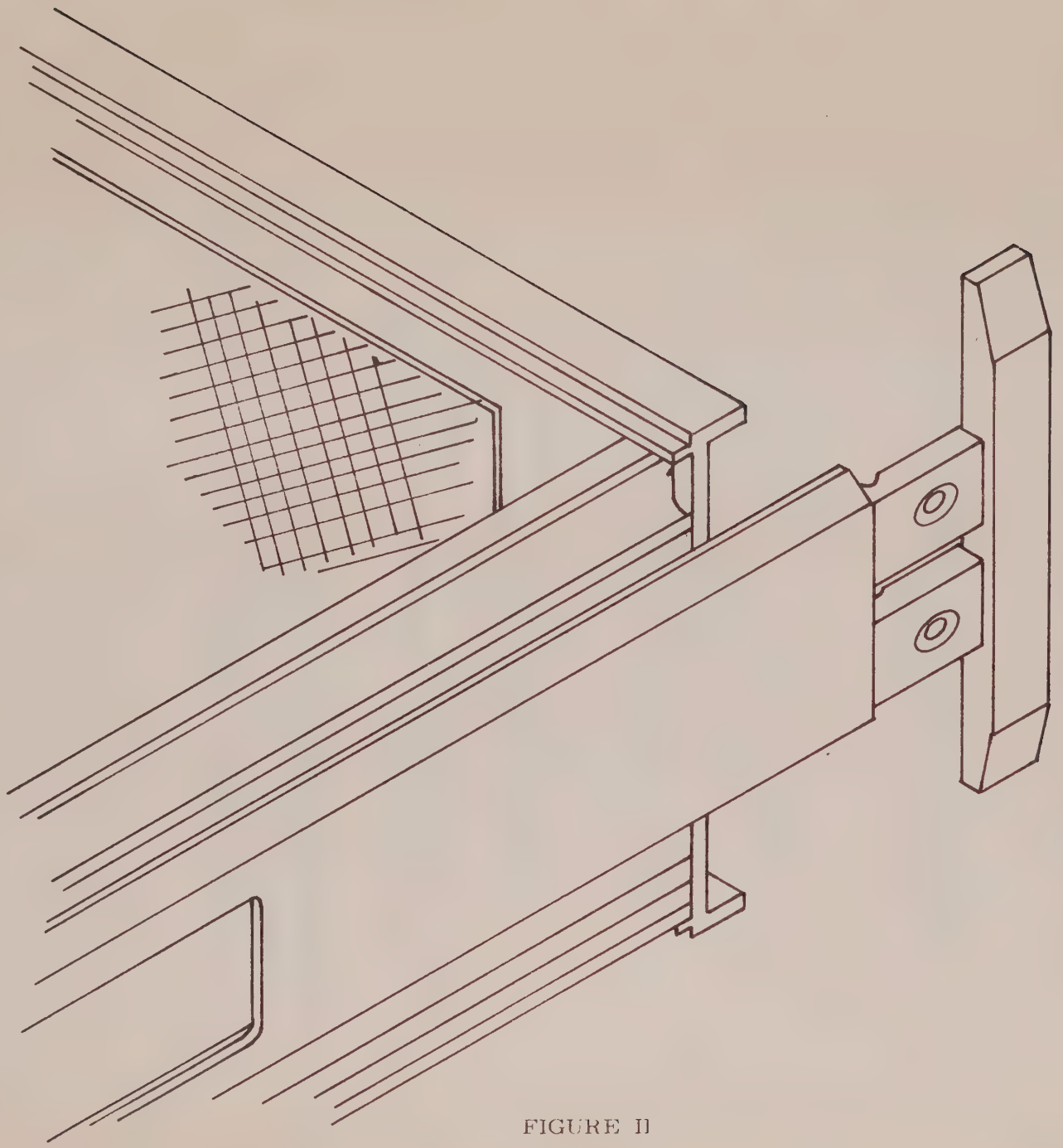


FIGURE II
REAR END CAPS

The use of low noise cable, such as Amphenol #21-537, will reduce the effects of cable flexing.

2.3 Repackage for Shipping

The following is a general rule for repackaging an instrument for shipment.

Place instrument in original container, if available. If original container is not available, a suitable one can be purchased from EG&G, Las Vegas.

If original container is not used:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.
b. Use plenty of packing material around all sides of instrument and protect panel faces with cardboard strips.
c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.
d. Mark shipping container with "DELICATE INSTRUMENT - FRAGILE."

The instrument should have a tag fixed to the instrument identifying the owner and indicating the service or repair to be accomplished (include the model number and full serial number of the instrument).

SECTION III - OPERATING INSTRUCTIONS

3.1 General

The Model ME-920 Automatic Picoammeter will measure DC currents with automatic adjustment of range and polarity determination. When operated with appropriate external circuitry, the instrument can be remotely controlled in all functions. The Model ME-920 will provide output information to an analog recorder, with provisions for monitoring polarity and range exponent (Option 01).

3.2 Front and Rear Panel Description

Following is a description of front and rear panel controls and indicators (Figure III).

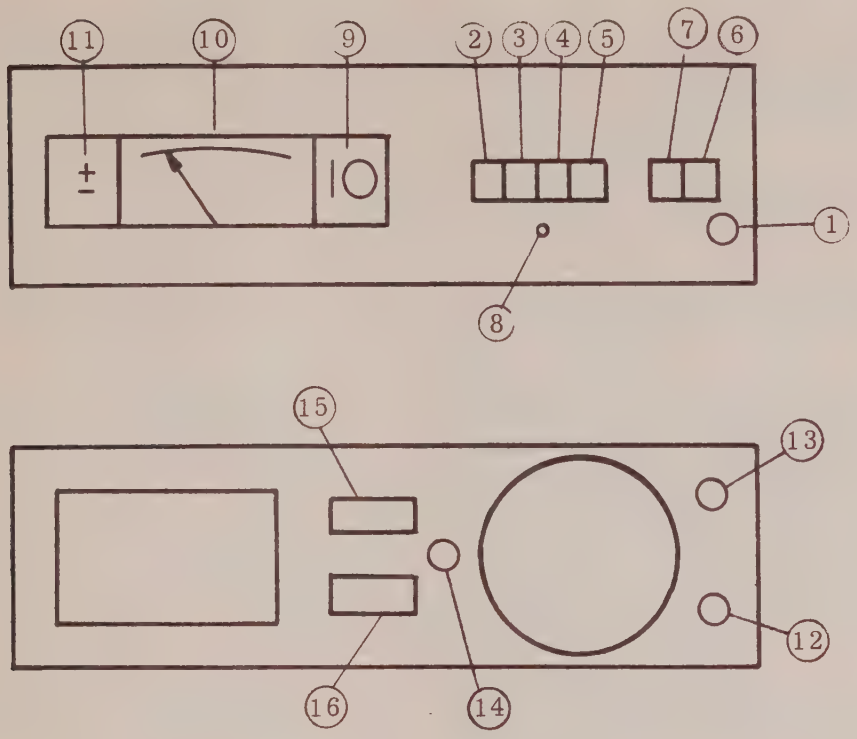


FIGURE III

(1)	INPUT	Input connector with shielding cap (BNC)
(2)	OFF	Turns instrument off
(3)	MAN	Places the instrument in the manual mode of operation
(4)	AUTO	Places the instrument in the automatic ranging mode of operation
(5)	REM	Enables remote programming of all front panel pushbutton functions. The pushing of any of the function switches except OFF turns the instrument on.

(6)	INC	Increases the sensitivity (range changes) of the instrument one decade at a time when in the MAN mode of operation
(7)	DEC	Decreases the sensitivity of the instrument
(8)	ZERO	Adjustment for zero input voltage offset ± 500 μv.
(9)	RANGE INDICATOR	Indicates the range or sensitivity of instrument. Number indicated is the negative exponent of 10, i.e., 9 is 10^{-9} amps full scale.
(10)	METER DISPLAY	Indicates the value of the current in amperes, 1.0 amps full scale times the range multiplier.
(11)	POLARITY INDICATOR	Automatically indicates the polarity of the input current
(12)	INPUT POWER CORD	
(13)	FUSE	3/4 Amp Slo-Blo Type 3AG
(14)	INPUT CONNECTOR	Rear, Optional
(15)	PRINTER CONNECTOR	
(16)	ACCESSORY CONNECTOR	

3.3 Operating Instructions

3.3.1 Turn-On Procedure

a. Connect the instrument to a grounded (three-wire) 105 - 125 v 60 Hz ± 5 Hz outlet.

b. Push MAN button and allow the instrument to warm up for ten minutes.

c. Place shield cap on the input connector.

d. Push sensitivity buttons until range indicator reads 8.

e. Adjust the instrument zero for an indicated polarity crossover, which will result in input voltage offset of typically ± 500 μv. The instrument is now ready for use.

For most general applications, the AUTO mode of operation will be most satisfactory. Under conditions of extreme noise, manual ranging might be necessary if the noise overlaps the up and down auto-ranging thresholds.

3.4 Remote Control

3.4.1 Connections

All front panel pushbutton functions may be remotely programmed. Mating connectors for Accessory and Printer are Amphenol 57-30240.

Programming is single point control to a remote common wire provided at the ACCESSORY connector.

NOTE: With no program lines activated, the function is AUTO. (See Figure IV)

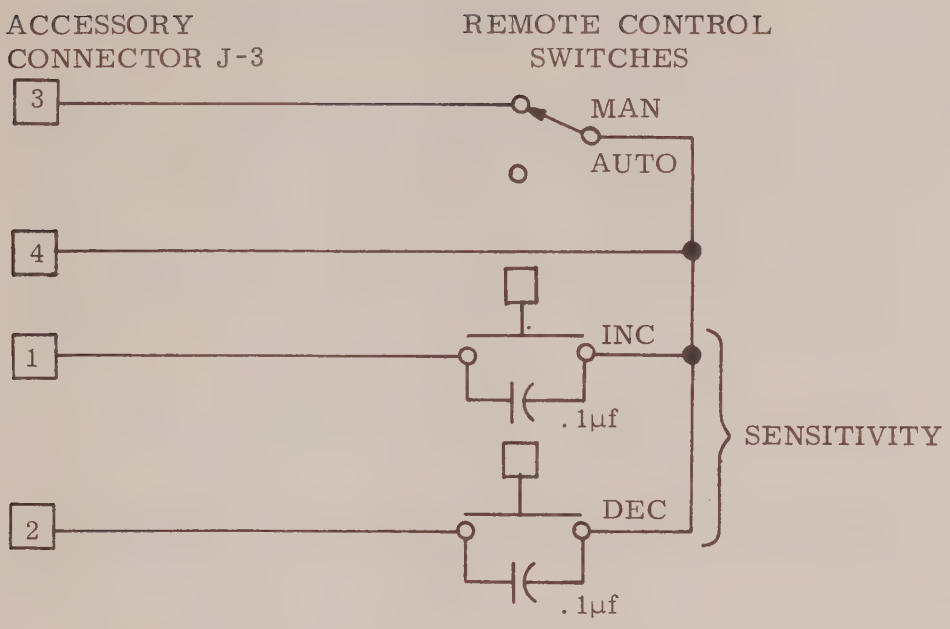


FIGURE IV

Active Function	Switch closure or saturated NPN transistor (+. 2 v max.), 2 ma sink
Inactive Function	Open circuit, +10 volts

Sensitivity programming requires addition of . 1 μf across remote program switch if contacts are used.

3. 4. 2 Operation

Perform Turn-On Procedure as outlined in Section 3. 3. 1.

Switch to REM. Instrument will now be remotely programmable.

SECTION IV - THEORY OF OPERATION

4.1 Input Circuitry and Range Changing

4.1.1 General

The EG&G ME-920 input amplifier consists of a high gain MOS FET operational amplifier with the range-changing feedback resistors switched with reed relays. An operational amplifier with resistive feedback as in Figure V will exhibit a transfer function:

$$Z_{21} = -\frac{V_o}{I_{in}} = Rf\left(\frac{R1}{R2} + 1\right) + R_1,$$

assuming the open loop gain is infinite and input offset voltage and current is zero.

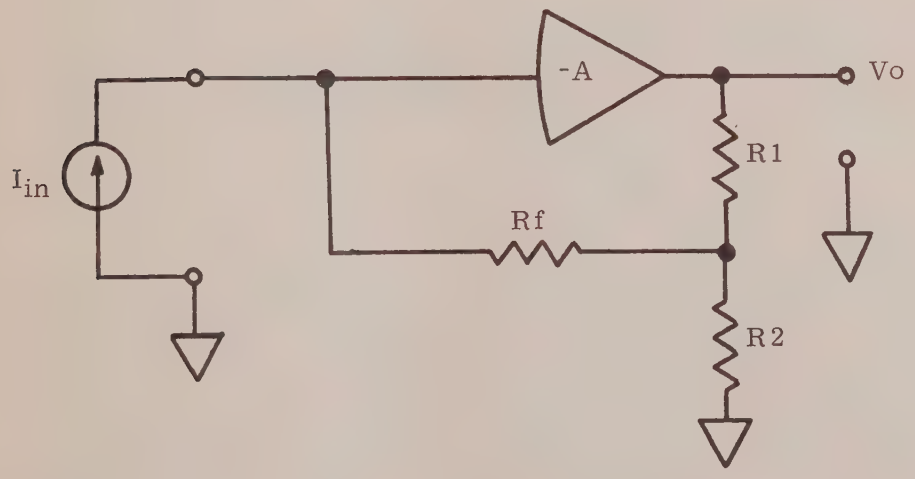


FIGURE V

In a practical circuit, these three conditions are never met and, depending on the degree to which they are approached, will dictate the specification of this type of current measuring amplifier. By controlling Rf, R1 and R2, any scaling of output voltage vs input current may be obtained.

In the ME-920, by varying the ratio of R1/R2 with a calibration potentiometer, the normal variation and drift in the high megohm feedback resistors may be compensated to achieve a high degree of accuracy. This procedure eliminates the replacement or direct measurement of feedback resistors for calibration.

4.1.2 Discussion

A simplified block diagram of the input amplifier and range control is shown in Figure VI. For a more detailed block diagram, refer to Section VI.

Current applied to the input of the MOS FET amplifier (A1) will result in an output voltage according to:

$$V_o \cong - I_{in} \times Rf \left(\frac{R1}{R2} + 1\right)$$

The full-scale output of A1 is +10 v to -10 v for negative and positive full-scale inputs, respectively. This output voltage is connected to an absolute value circuit. This circuit senses the output polarity of A1 and inserts an inverting amplifier in series with the output for negative voltages and passes the voltage straight through for positive voltages. This converts a bi-polar (-10 v to +10 v) signal out of A1 to a unipolar (0 v to +10 v) signal at the absolute value output. The polarity sensing circuit also illuminates the correct polarity sign on the front panel indicator.

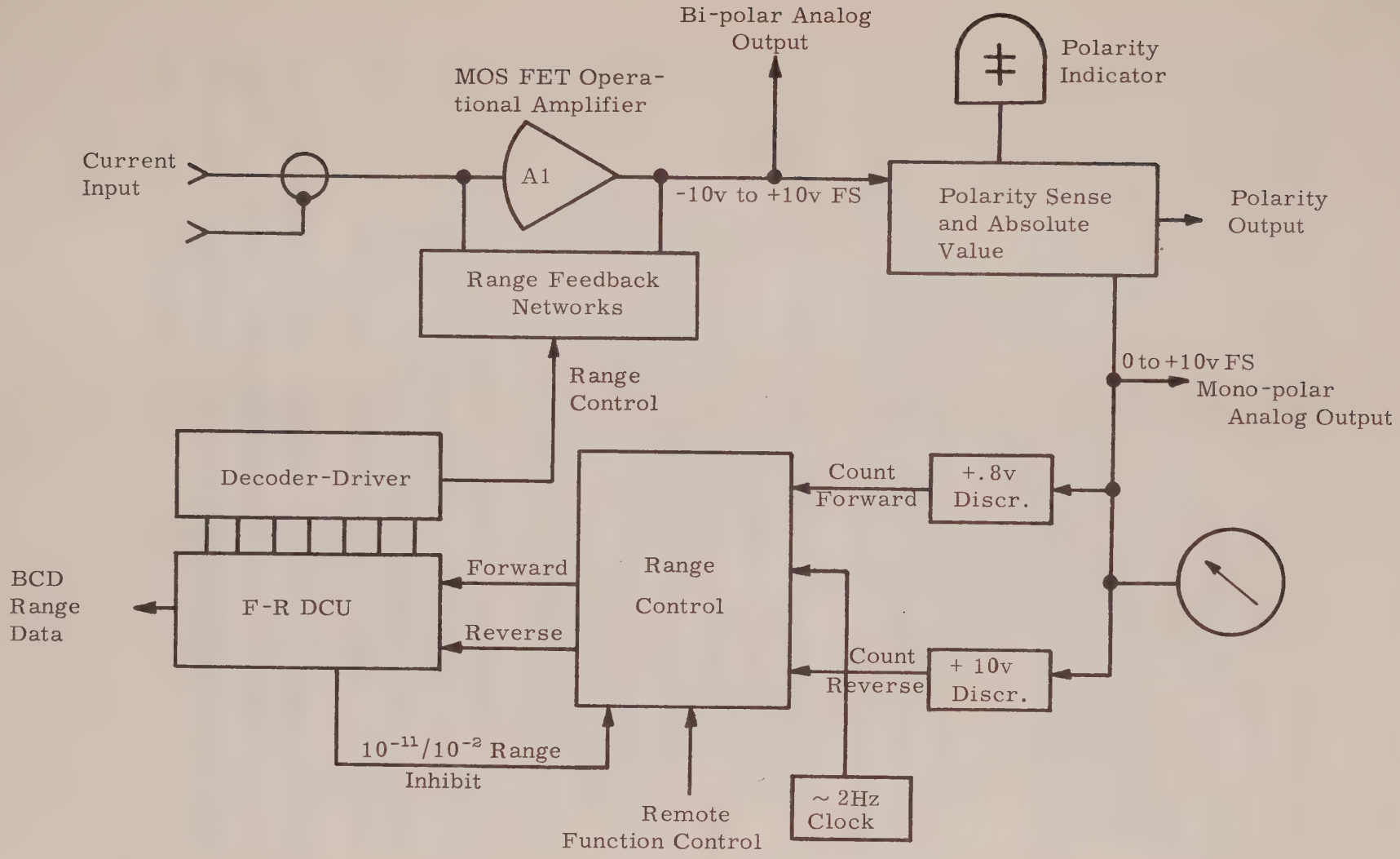

Bi-polar Analog Output
Polarity Indicator
MOS FET Operational Amplifier
Current Input
A1
-10v to +10v FS
Polarity Sense and Absolute Value
Polarity Output
Range Feedback Networks
0 to +10v FS Mono-polar Analog Output
Range Control
Decoder-Driver
Count Forward
+.8v Discr.
BCD Range Data
F-R DCU
Forward
Reverse
Range Control
Count Reverse
+ 10v Discr.
$10^{-11}/10^{-2}$ Range Inhibit
Remote Function Control
~ 2Hz Clock

FIGURE VI

Any given state (0 thru 9) of the forward-reverse decimal-counting unit (DCU) will result in a discrete combination of feedback elements to be connected to A1 via the decoder-driver and reed relays. State "0" is equivalent to 10^{-2} amps full scale, state "1", 10^{-3} amps, etc., to state "9", 10^{-11} amps. One pulse applied to the forward input of the Forward-Reverse DCU will increase the state of the DCU to the next increment (i.e., "8" to "9") and one pulse applied to the reverse input will decrease the state one increment.

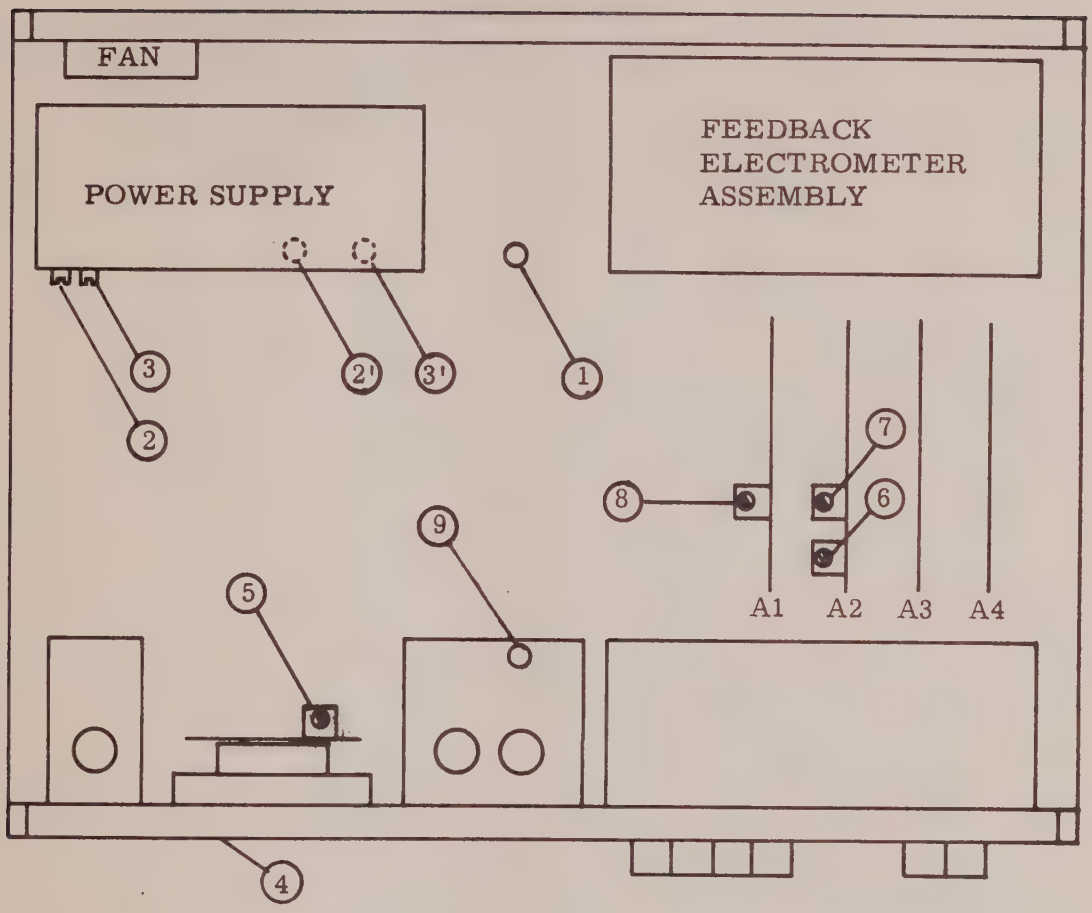
Outputs from the DCU are also used to inhibit auto or manual ranging below 0 or above 9, since this will cause a change in state equivalent to ten decades of sensitivity in the wrong direction.

The output of the absolute value is applied to two adjustable discriminators, one set at +.8 volts (8% F.S.) and one at +10 volts (100% F.S.). An absolute value output in excess of +10 volts will allow the 10 Hz clock to be applied to the reverse input of the DCU decreasing A1 sensitivity. The pulses will be applied as long as the absolute value is in excess of +10 volts, or until the DCU reaches "0", equivalent to maximum full-scale input of 10^{-2} amps.

An output <u>less</u> than +.8 volts will cause pulses to count the DCU forward until the sensitivity is increased sufficiently to cause greater than 8% full scale input on a given range, or until the DCU reaches "9", equivalent to the most sensitive range of 10^{-11} amps.

In the manual mode, each depression of the INC or DEC pushbuttons will allow one pulse to be applied to the forward or reverse inputs of the DCU, respectively. Thus increasing or decreasing the range sensitivity by one decade.

Because of range overlap in the automatic mode, a value of current between 80% and 100% of full scale on a given range might possibly be displayed on the next less-sensitive range.



ADJUSTMENT POTENTIOMETER AND P. C. CARD LOCATIONS

FIGURE VIII

1 Signal Common Access

2 -15 volt Power Supply Adjustment

2' -15 volt Power Supply Access

3 +15 volt Power Supply Adjustment

3' +15 volt Power Supply Access

4 Mechanical Meter Zero

5 Meter Full Scale Calibration

6 Auto Increase Threshold Adjustment

7 Auto Decrease Threshold Adjustment

8 Absolute Value Zero

9 185V Access

SECTION V - MAINTENANCE

5.1 Performance Checks

5.1.1 General

These test may be performed to verify proper operation exclusive of range calibration. (Refer to Section 5.2.5)

5.1.2 Test Equipment Required

Precision Power Supply -- Accuracy ± .05% or better

Millivoltmeter -- Sensitivity 3mv full scale

5.1.3 Control Circuitry Performance Checks (Reference Figure VII)

1. Remove the Absolute Value Card A1 from its socket.
   Connect a power supply to XA1.
   Pin 10 -- Positive power supply lead
   Pin 14 -- Negative power supply lead
2. Switch instrument to MAN, range to 8.
3. Adjust power supply to ~ 5v.
4. Switch instrument to AUTO.
5. As the power supply is adjusted in excess of 10 volts ± .1 volts, the range exponent indicator will step to 2. Adjusting the power supply below .8 volts ± .05 volts will cause the range exponent indicator to step to 11.
6. Remove external power supply. Reinsert Absolute Value Card A1.
7. Switch to MAN. Manually range instrument to 6.
8. Connect the millivoltmeter to XA1, Absolute Value:
   Positive Lead -- Pin 2
   Negative Lead -- Pin 14
9. Adjust the front panel ZERO control to indicate 5 to 10mv <u>negative</u> on the millivoltmeter. Record this voltage.
10. Connect the positive millivoltmeter lead to Pin 10 XA1. Record this voltage.

11. The two voltages (Steps 9 and 10) must be opposite in sign, and the difference in Absolute Value between the two, +3 mv.

5.1.4 Meter Calibration Check

1. Remove Absolute Value Card A1.
2. Connect the precision power supply to XA1.
   Positive Lead -- Pin 10
   Negative Lead -- Pin 14
3. Adjust power supply to 10 volts. Meter must indicate full scale ±.5% full scale.

5.2 Instrument Calibration

5.2.1 Power Supply Adjustment

Power supply voltage access and adjustments are shown in Figure VII Tolerance on ±15 volt supplies are ±30mv. Adjustment necessitates removal of A9, A10 and A11. Plus 185 volt power supply tolerance is ±15 volts with no adjustments provided.

5.2.2 Test Equipment Required

1. Precision power supply -- Accuracy ±.05% or better.
2. Millivoltmeter ±3mv full scale sensitivity.
3. EG&G TF-601 Pico-Calibrator or precision current source.
4. Digital voltmeter (optional -- See 5.2.5.2)

5.2.3 Meter Calibration (Reference Figure VII)

1. With power off, adjust mechanical meter zero (4).
2. Remove Absolute Value Card A1. Connect the precision power supply to XA1:
   Positive Lead -- Pin 10 (Pin 11 ~ 920 ~ 930)
   Negative Lead -- Pin 14
3. Adjust power supply to 10 volts.
4. Adjust Meter Calibration Potentiometer (5) to indicate full scale.
5. Reinsert Absolute Value Card A1.

5.2.4 Input Circuitry and Range Changing

5.2.4.1 Range Changing Calibration (Reference Figure VII)

1. Remove Absolute Value Card A1. Connect the precision power supply to XA1:

   Positive Lead -- Pin 10

   Negative Lead -- Pin 14

2. Rotate Increase Potentiometer (6) on A2 fully counter-clockwise.
3. Rotate Decrease Potentiometer (7) on A2 fully clockwise.
4. Adjust power supply to 10 volts.
5. Switch instrument on MAN.
6. Range instrument to 6. Switch to AUTO.
7. Rotate Decrease Potentiometer (7) counter-clockwise until range steps automatically to 2.
8. Adjust power supply to .8 volts.
9. Verify range is at 2; if not, manually set range to 2 and switch back to AUTO.
10. Adjust Increase Potentiometer (6) clockwise until range automatically steps to 11.

    NOTE: Range thresholds may be adjusted by inserting a current into the instrument and using the meter display to set 1.0 (full scale) and .08 (8% full scale) for Steps 4 and 8, respectively. (With this method, auto-ranging will step only one decade of sensitivity.)

11. Reinsert Absolute Value A1.

5.2.4.2 Absolute Value

1. Range instrument manually to 6.
2. Connect the millivoltmeter to XA1:

   Positive Lead -- Pin 2

   Negative Lead -- Pin 14

3. Adjust the front panel ZERO potentiometer to indicate 5 to 10 millivolts negative on the millivoltmeter. Record this voltage.

4. Connect the millivoltmeter positive lead to Pin 10. Adjust the Absolute Value Zero Potentiometer (8) to indicate the same magnitude (±500μv) in Step 3, but positive in polarity.

5.2.5 Calibration of Hi-Meg Ranges

5.2.5.1 Theory of Calibration

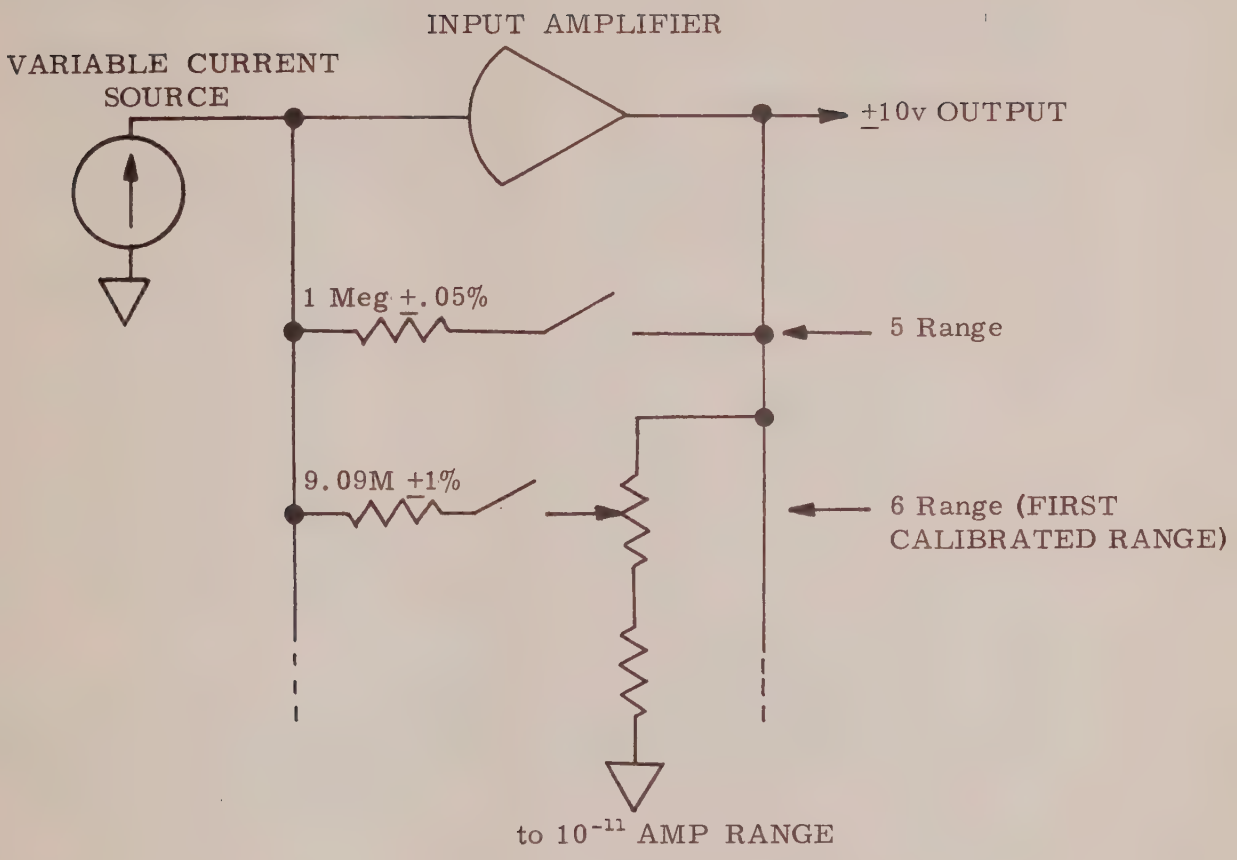
The technique used in this calibration procedure is a "bootstrap" method. (Reference Figure VIII) For example, starting with the instrument in the 5 range, the variable current source is adjusted for an output of exactly ten volts. (This would be displayed on the meter as 1.0.) Then, the variable current source is divided down by a factor of ten with a precision divider.* The range sensitivity is now increased a factor of 10 to Range 6. The output divider in the Picoammeter is adjusted for an output of 10 volts (1.0 full scale).

The same procedure is now continued, using the 6 range as a reference. This procedure will provide an input current from the variable source subject to the following inaccuracies:

1. Precision of the reference resistor
2. Input amplifier voltage offset
3. Resolution and accuracy of the set point -- ADC (meter display or analog output).
4. Voltage coefficient of the current source when dividing by 10.
5. Input amplifier current offset.

ME-920 accuracy specifications include these possible contributions to error in worst accumulative case using the TF-601 as the calibration source. Fixed precision current sources may be used for calibration with possible improvement in accuracy specification.

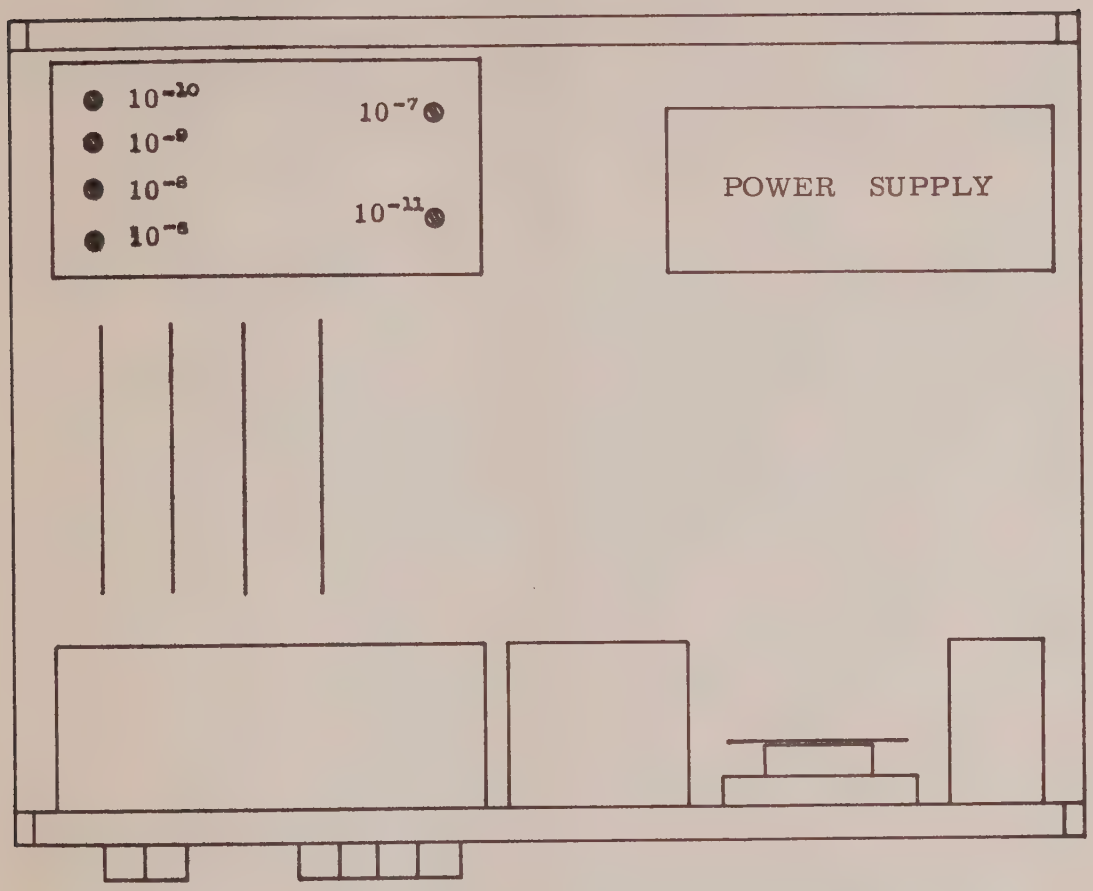
* Voltage coefficients with high meg resistors in the current source are kept to a minimum by use of .01% per volt resistors in the TF-601. This non-linearity is accounted for in the specification of accuracy when the ME-920 series is calibrated with the TF-601.



BOOTSTRAP CALIBRATION SYSTEM

FIGURE VIII

FEEDBACK & ELECTROMETER
ASSEMBLY



RANGE CALIBRATION ACCESS

(Bottom View)

FIGURE IX

5.2.5.2 Procedure

This calibration procedure is applicable with the use of the EG&G Model TF-601 Pico-Calibrator. A digital voltmeter may be used to monitor the analog output (mono- or bi-polar) for increased accuracy of calibration. Reference in the text will be full-scale, meaning either 10.00 volts on the DVM or 1.0 displayed by the meter movement.

1. Remove bottom cover of ME-920. Set instrument on its side for access to the range calibration potentiometers on the underside of the shield box. (Reference Figure IX)
2. Connect the TF-601 interconnecting cable to the ME-920 ACCESSORY connector at the rear of the instrument.
3. Connect the coaxial cable to the ME-920 input.
4. Switch the 601 controls to the following positions:

Current	Off
Range	11
Variable	-
Multiplier	10

5. Depress MAN pushbutton on the ME-920, step range to 8.
6. Allow ten minutes warm-up.
7. Adjust the ZERO control to indicate 0.000 and polarity crossover.
8. Manually range ME-920 to 5.
9. Switch 601 RANGE to 6 and CURRENT to +.
10. Adjust VARIABLE on 601 to indicate full scale.
11. Switch MULTIPLIER to 1.
12. Range 920 to 6.
13. Adjust 10^{-6} Calibration Potentiometer to indicate full scale.
14. Switch RANGE on 601 to 7.
15. Switch MULTIPLIER on 601 to 10.

16. Adjust VARIABLE for full scale.
17. Switch MULTIPLIER to 1.
18. Range 920 to 7.
19. Adjust 10^{-7} Calibration Potentiometer to indicate full scale.
20. Switch RANGE to 8.
21. Switch MULTIPLIER to 10.
22. Adjust VARIABLE for full scale.
23. Switch MULTIPLIER to 1.
24. Range 920 to 8.
25. Adjust 10^{-8} Calibration Potentiometer to indicate full scale.
26. Switch RANGE to 9.
27. Switch MULTIPLIER to 10.
28. Adjust VARIABLE for full-scale.
29. Switch MULTIPLIER to 1.
30. Range 920 to 9.
31. Adjust 10^{-9} Calibration Potentiometer to indicate full scale.
32. Switch RANGE to 10.
33. Switch MULTIPLIER to 10.
34. Adjust VARIABLE for full scale.
35. Switch MULTIPLIER to 1.
36. Range 920 to 10.
37. Adjust 10^{-10} Calibration Potentiometer to indicate full-scale.
38. Switch RANGE to 11.
39. Switch MULTIPLIER to 10.
40. Adjust VARIABLE to full scale.
41. Switch MULTIPLIER to 1.
42. Range 920 to 11. For highest accuracy, allow at least one minute for stabilization at this step.

43. Adjust 10^{-11} Calibration Potentiometer to indicate full scale ±.1% F.S.* Allow sufficient time for stable indications at this step. Each digit now represents 10^{-14} amps of input current, so coaxial cable movement must be avoided to make noise-free adjustments.

44. Repeat Steps 6 through 42. This is necessary, since resistors are added accumulatively in the feedback as sensitivity is decreased, resulting in some interaction between ranges.

Zero offset checking may be accomplished at any step during calibration by switching TF-601:

CURRENT	Off
RANGE	11 and by switching

ME-920:

RANGE	8

and adjusting for polarity crossover.

---

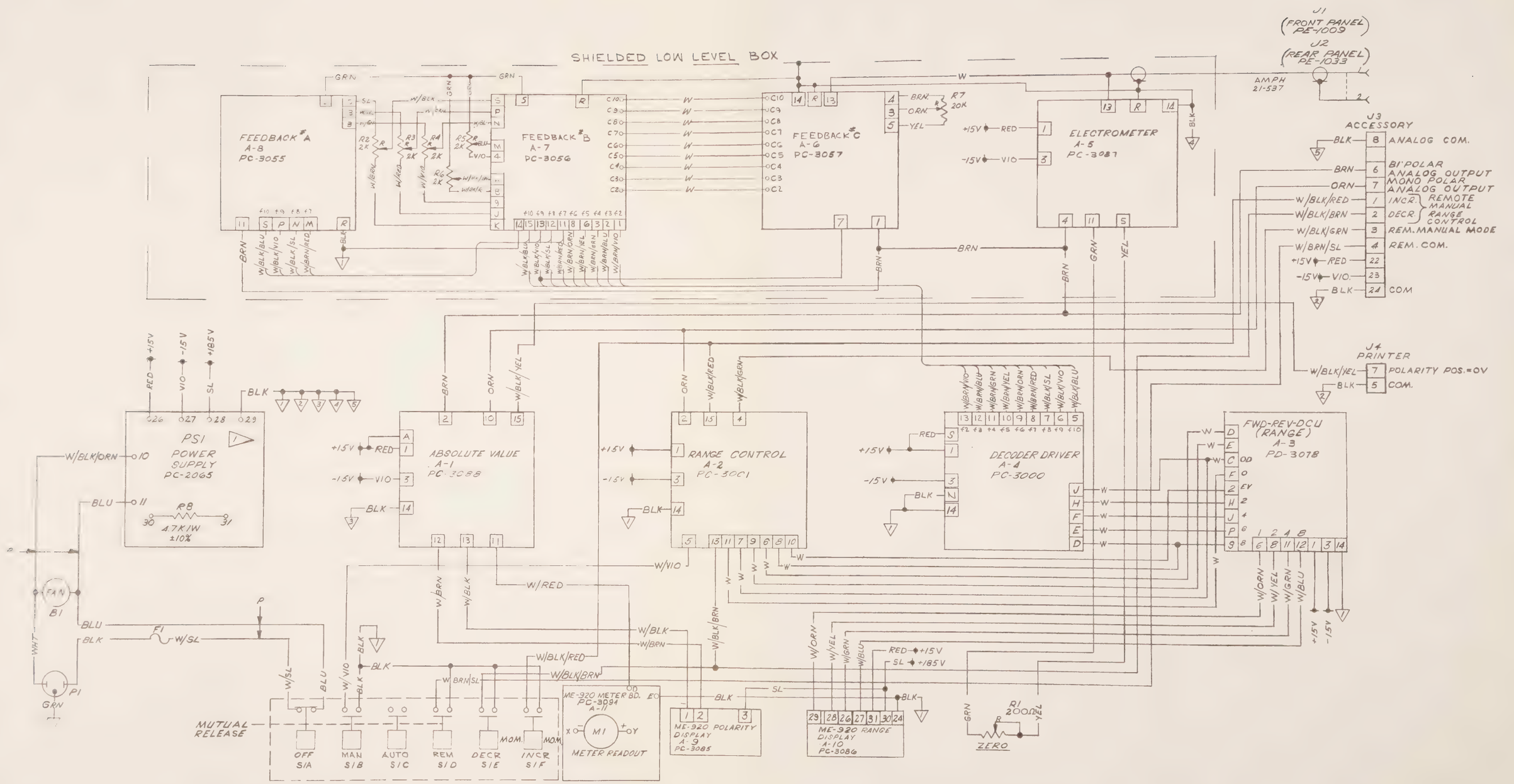
*Normal self input current on the ME-920 is < 10^{-13} amperes. This offset may be compensated for by:

1. Remove coaxial cable and replace shield cap, range 920 to 11.
2. Allow one minute for stabilization, record the offset. For example: +.5% F.S.
3. At Step 42, adjust full scale to +99.5% F.S. ± .1% F.S. to compensate for input offset current as determined in Step 2.

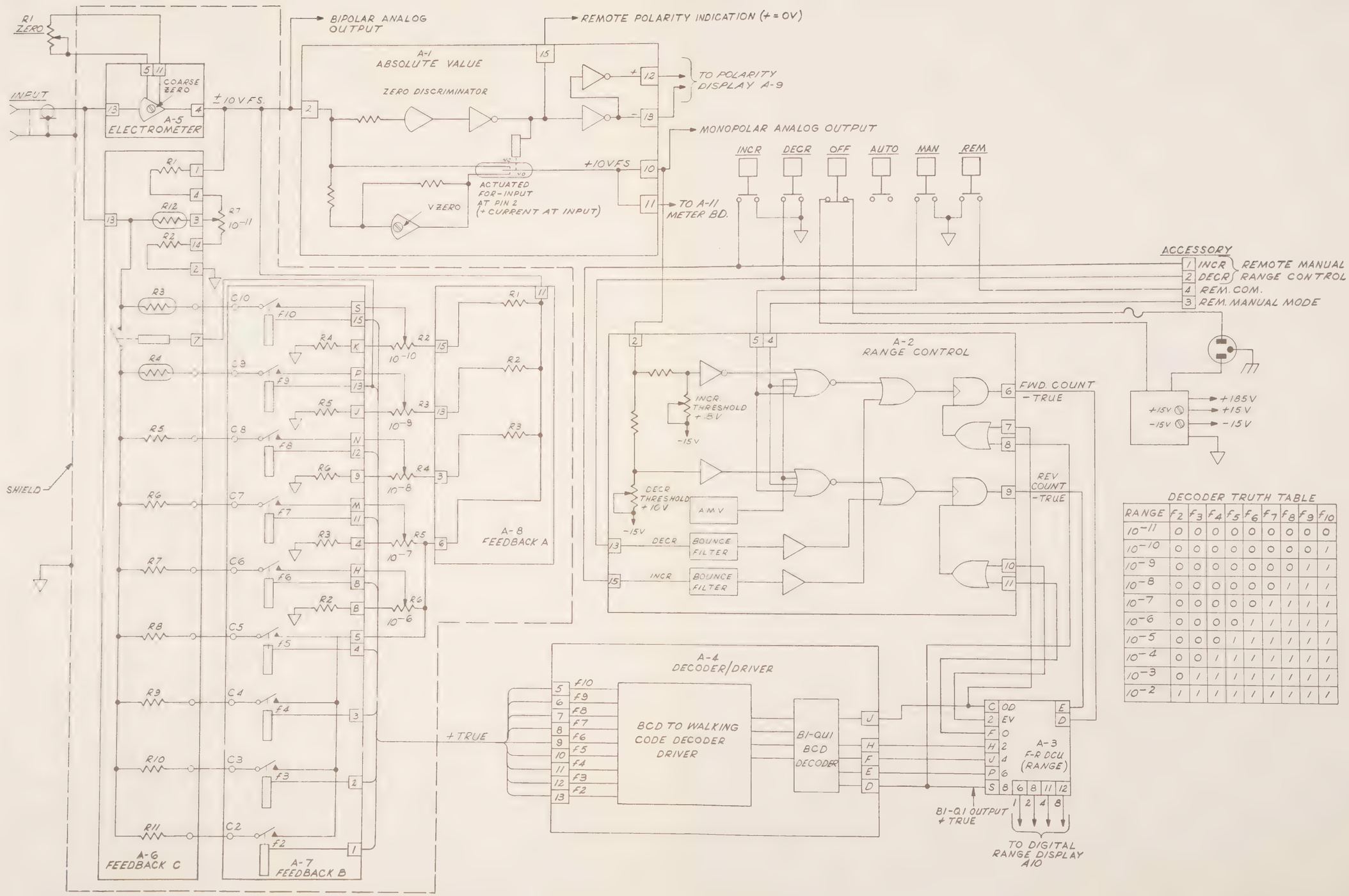
SECTION VI - CIRCUIT DIAGRAMS

6.1 Introduction

This section contains the circuit diagrams necessary for maintenance of the Model ME-920. Schematics, component location drawings and a wiring diagram are included. The location drawings show the physical location of each component on each circuit board and they accompany the appropriate schematic. The wiring diagram shows the connections between all the circuit boards and chassis components.

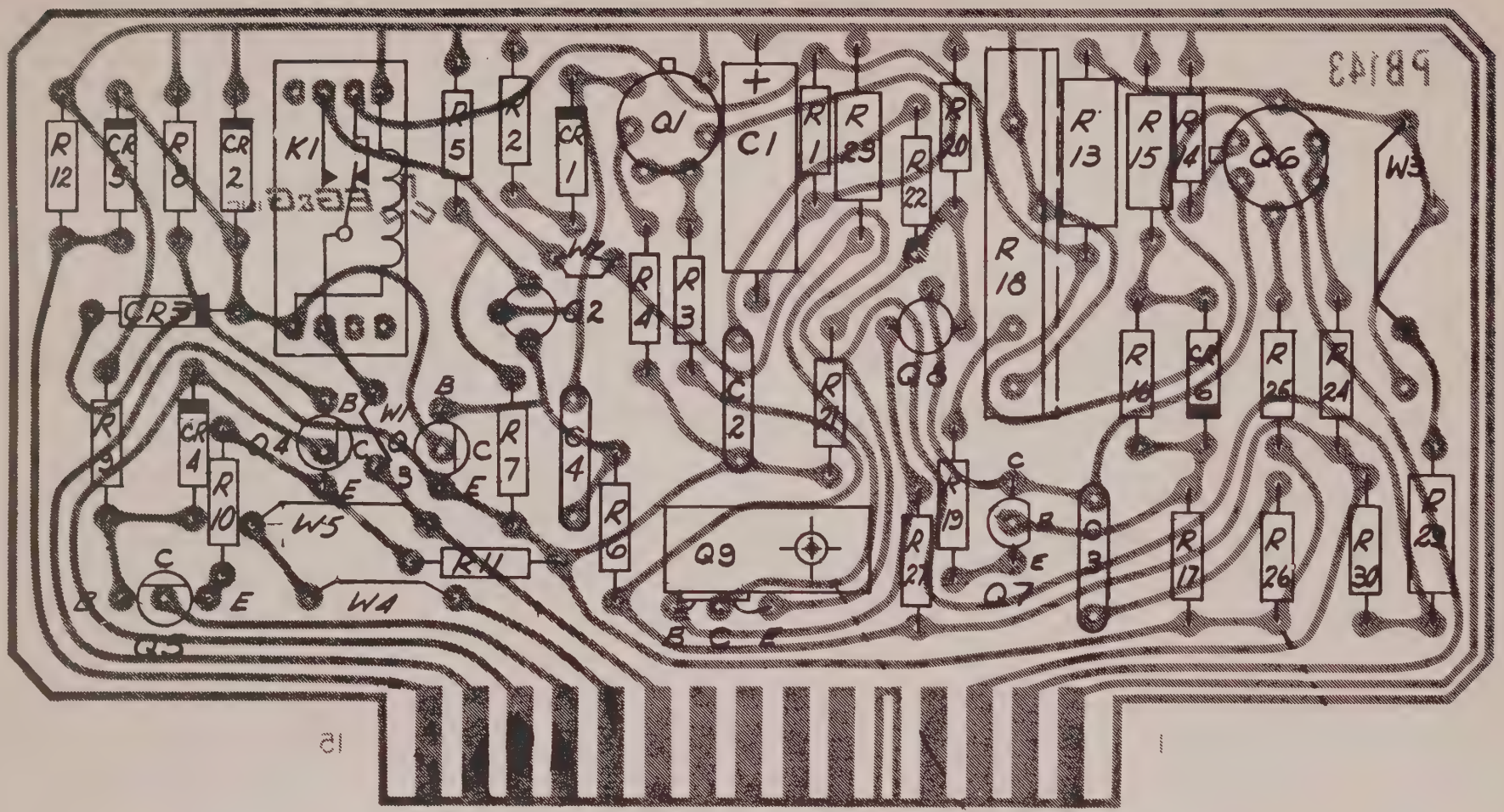


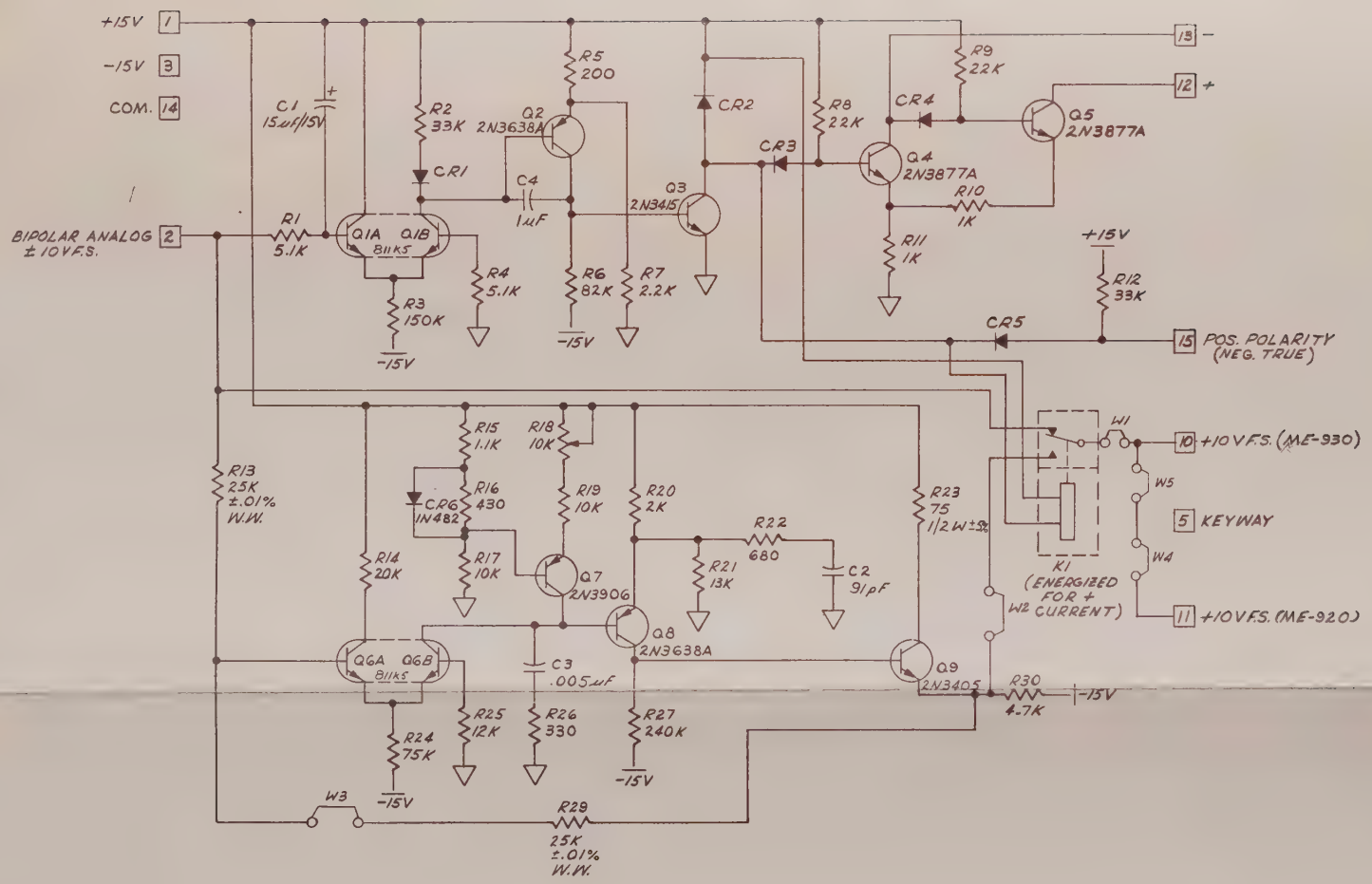
SCHEMATIC DIAGRAM ME-920

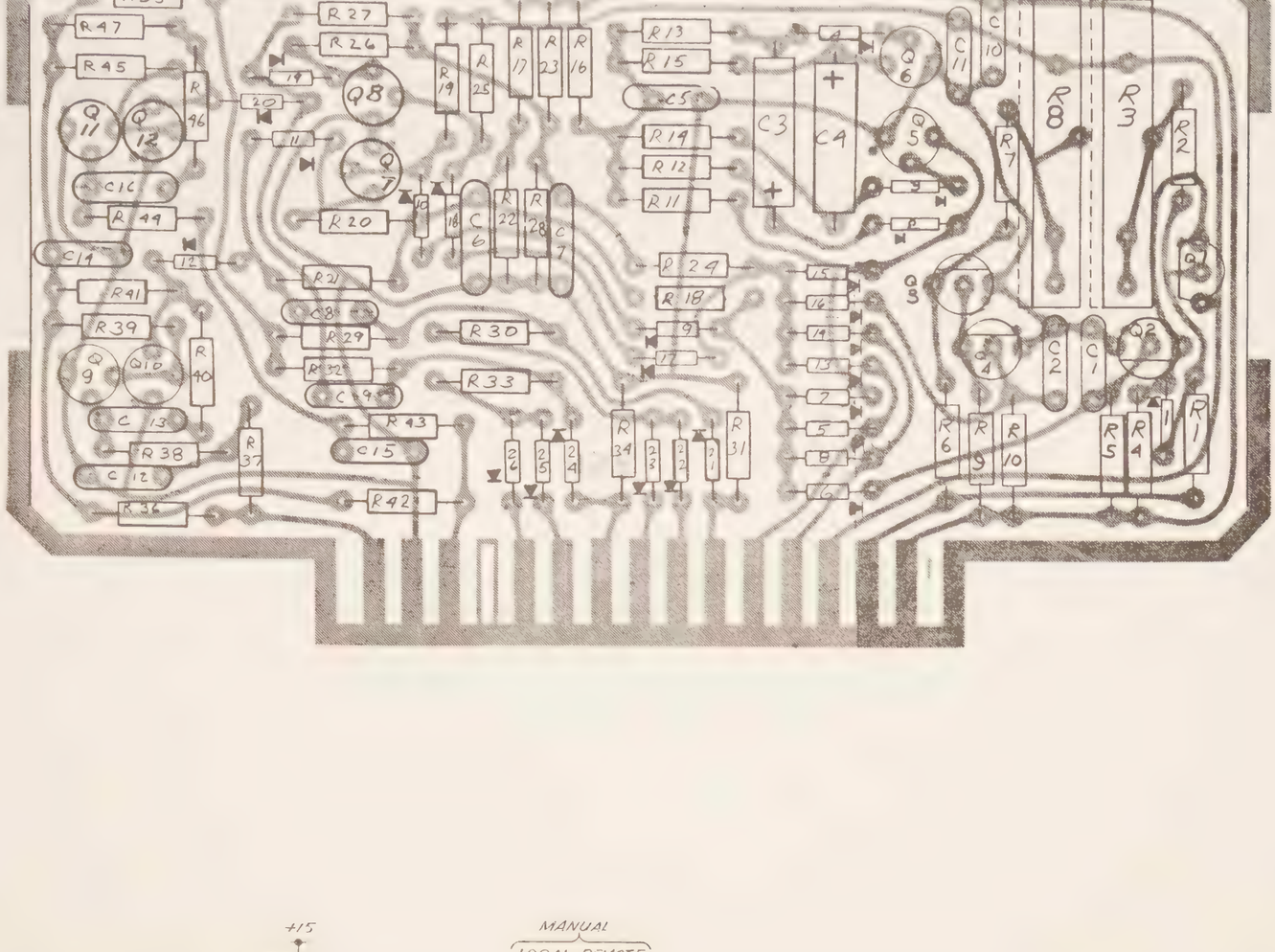


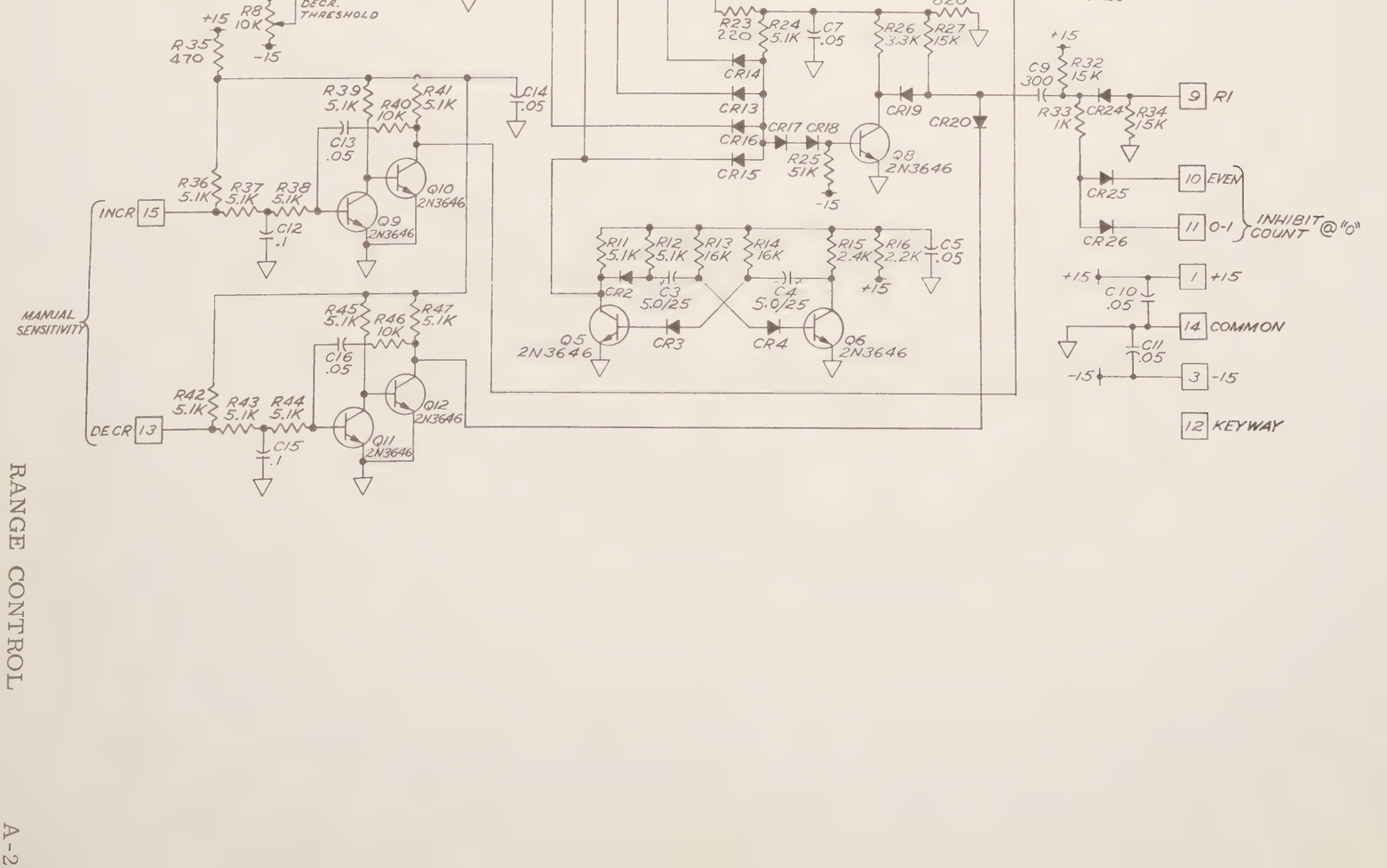
DECODER TRUTH TABLE

RANGE	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}
10^{-11}	0	0	0	0	0	0	0	0	0
10^{-10}	0	0	0	0	0	0	0	0	1
10^{-9}	0	0	0	0	0	0	0	1	1
10^{-8}	0	0	0	0	0	0	1	1	1
10^{-7}	0	0	0	0	0	1	1	1	1
10^{-6}	0	0	0	0	1	1	1	1	1
10^{-5}	0	0	0	1	1	1	1	1	1
10^{-4}	0	0	1	1	1	1	1	1	1
10^{-3}	0	1	1	1	1	1	1	1	1
10^{-2}	1	1	1	1	1	1	1	1	1

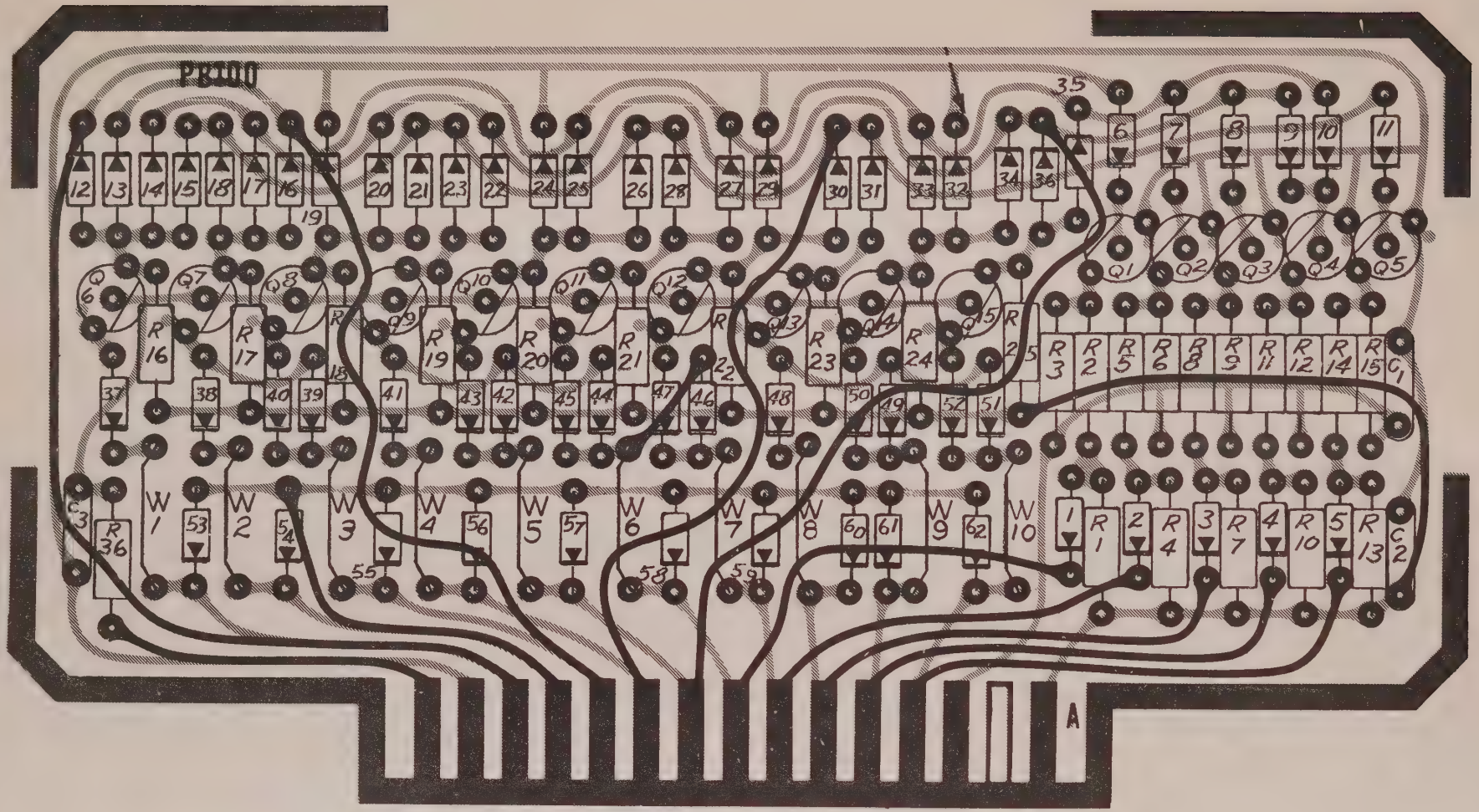

K1
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
C1
C2
W1
W2
W3
W4
W5
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
R24
R26
R27
R30
CR1
CR2
CR3
CR4
CR5
CR6
B
C
E

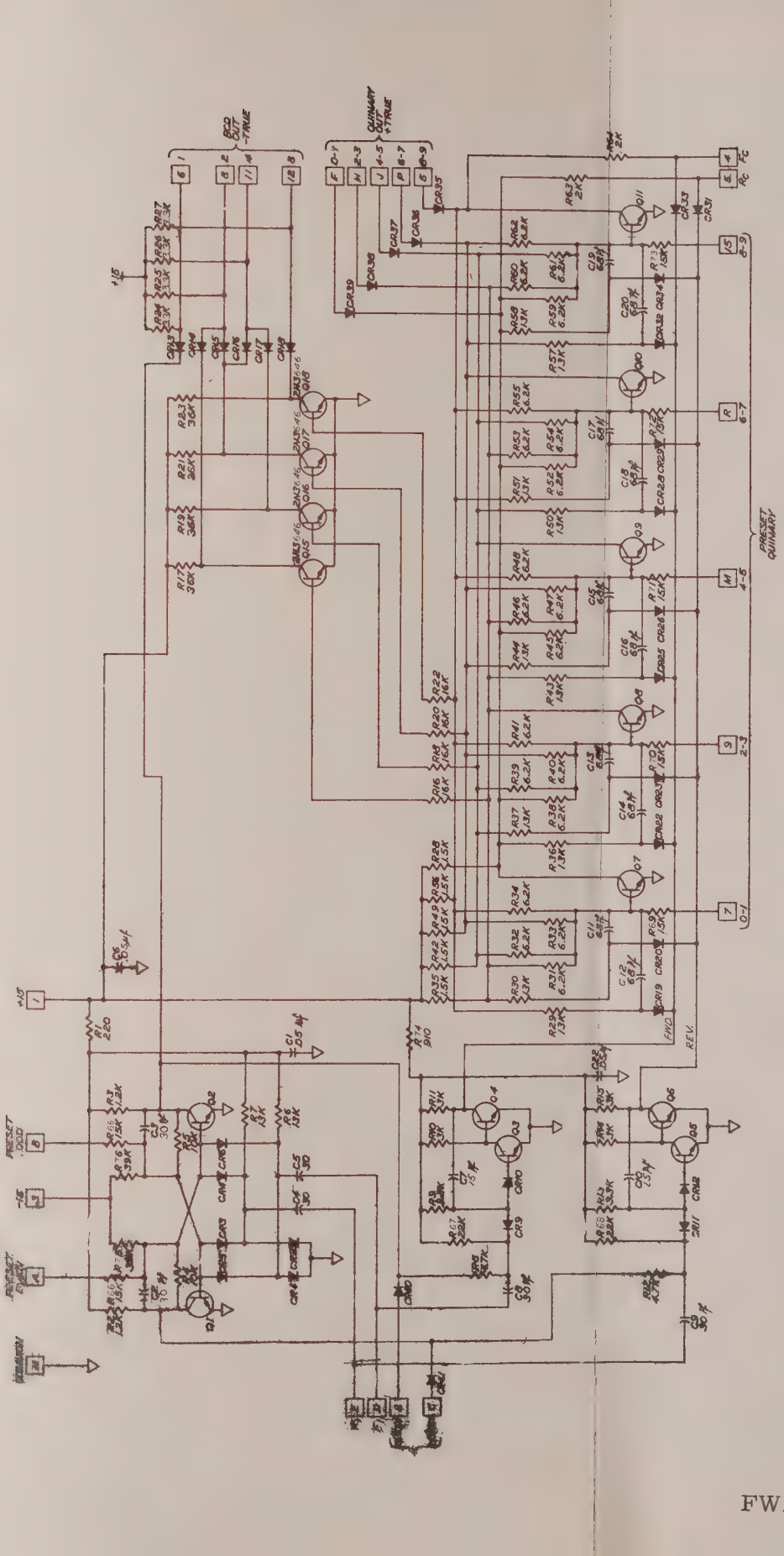

+15V 1
-15V 3
COM. 14
C1 15μf/15V
R2 33K
CR1
Q2 2N3638A
R5 200
C4 1μF
CR2
Q3 2N3415
R8 22K
CR3
CR4
R9 22K
Q5 2N3877A
Q4 2N3877A
R10 1K
R11 1K
15 -
12 +
BIPOLAR ANALOG ±10V F.S. 2
R1 5.1K
Q1A Q1B Bilks
R4 5.1K
R3 150K
R6 82K
R7 2.2K
+15V
R12 33K
CR5
15 POS. POLARITY (NEG. TRUE)
R13 25K ±.01% W.W.
R15 1.1K
R18 10K
CR6 IN482
R16 430
R19 10K
R20 2K
R22 680
R21 13K
C2 91pF
R14 20K
R17 10K
Q7 2N3906
Q8 2N3638A
R23 75 1/2W ±2%
W1
10 +10 V F.S. (ME-930)
W5
5 KEYWAY
W4
K1 (ENERGIZED FOR + W2 CURRENT)
11 +10V F.S. (ME-920)
Q6A Q6B Bilks
C3 .005μF
Q9 2N3405
R30 4.7K
R24 75K
R25 12K
R26 330
R27 240K
W3
R29 25K ±.01% W.W.



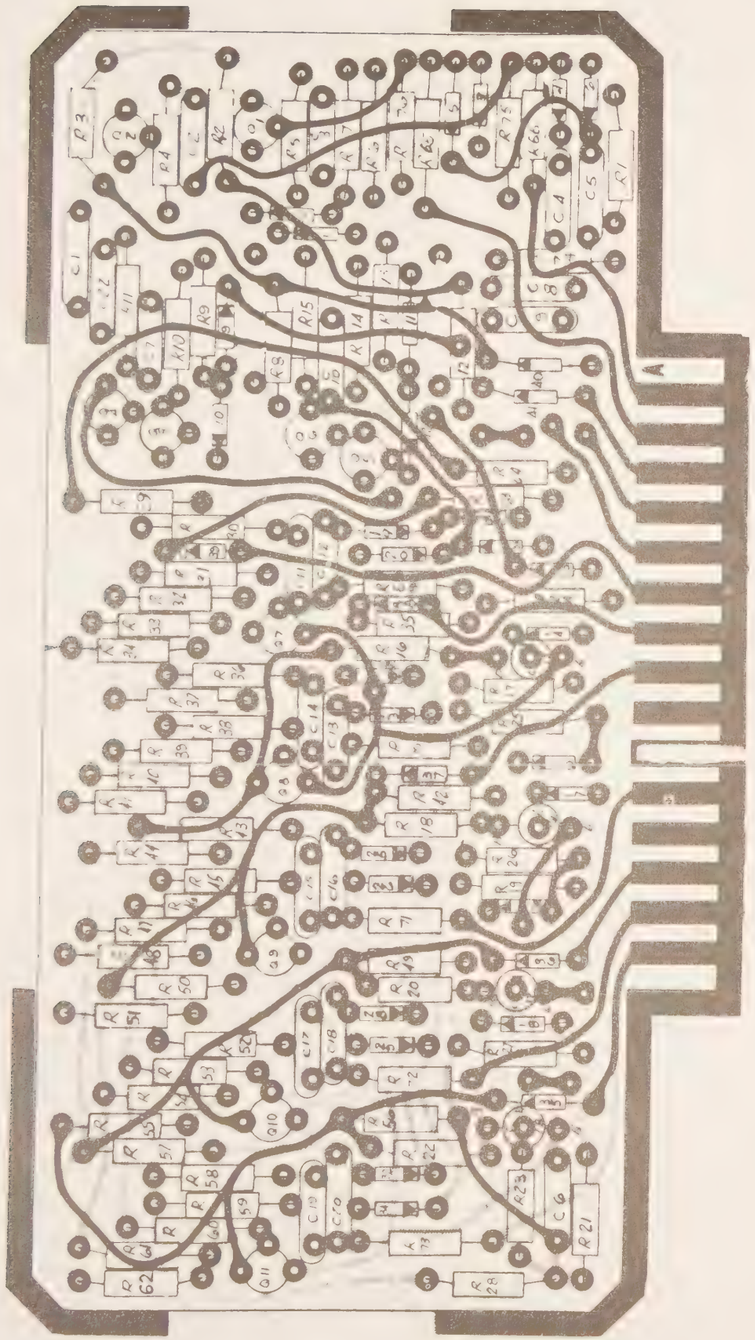


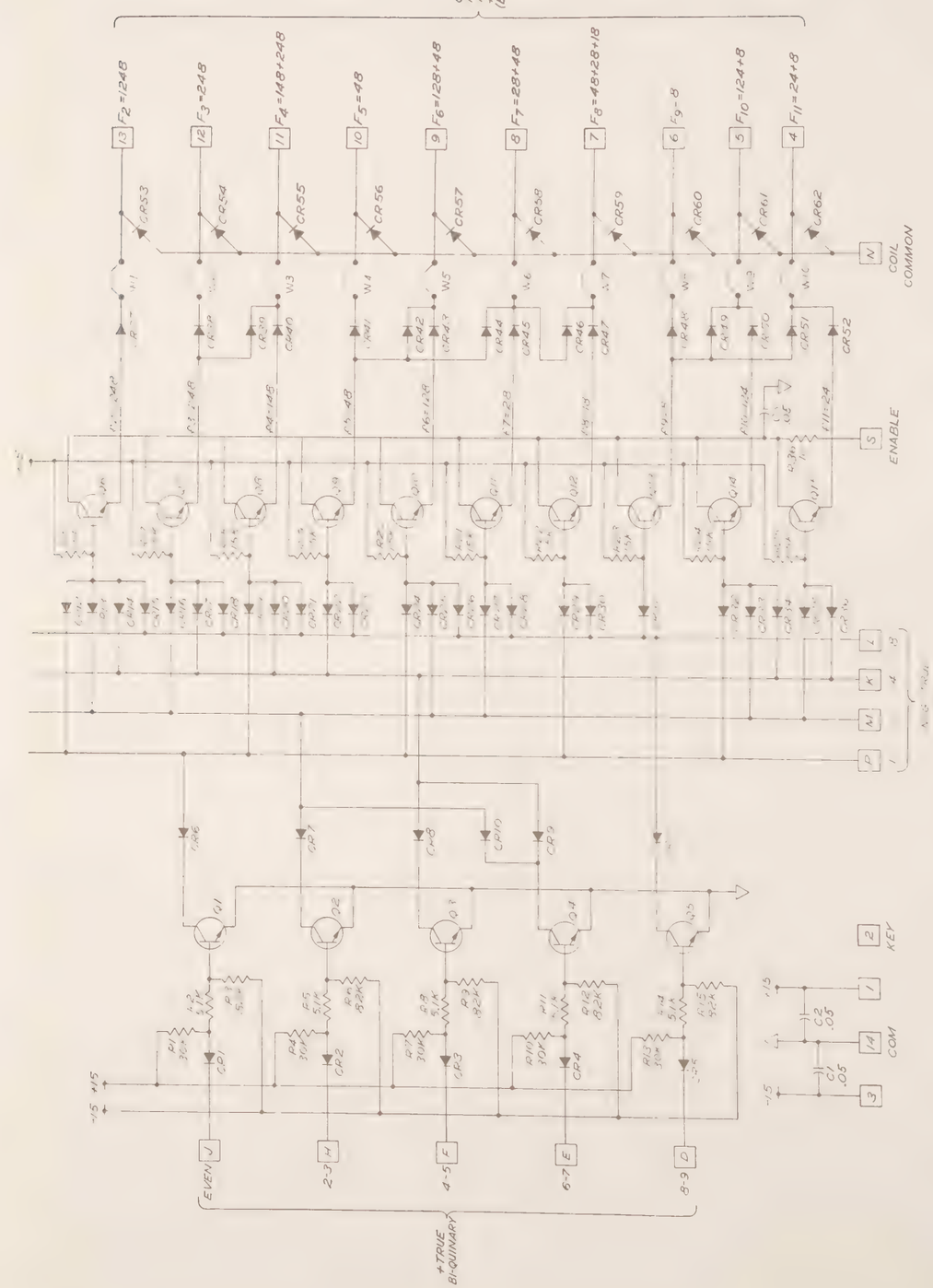
RANGE CONTROL

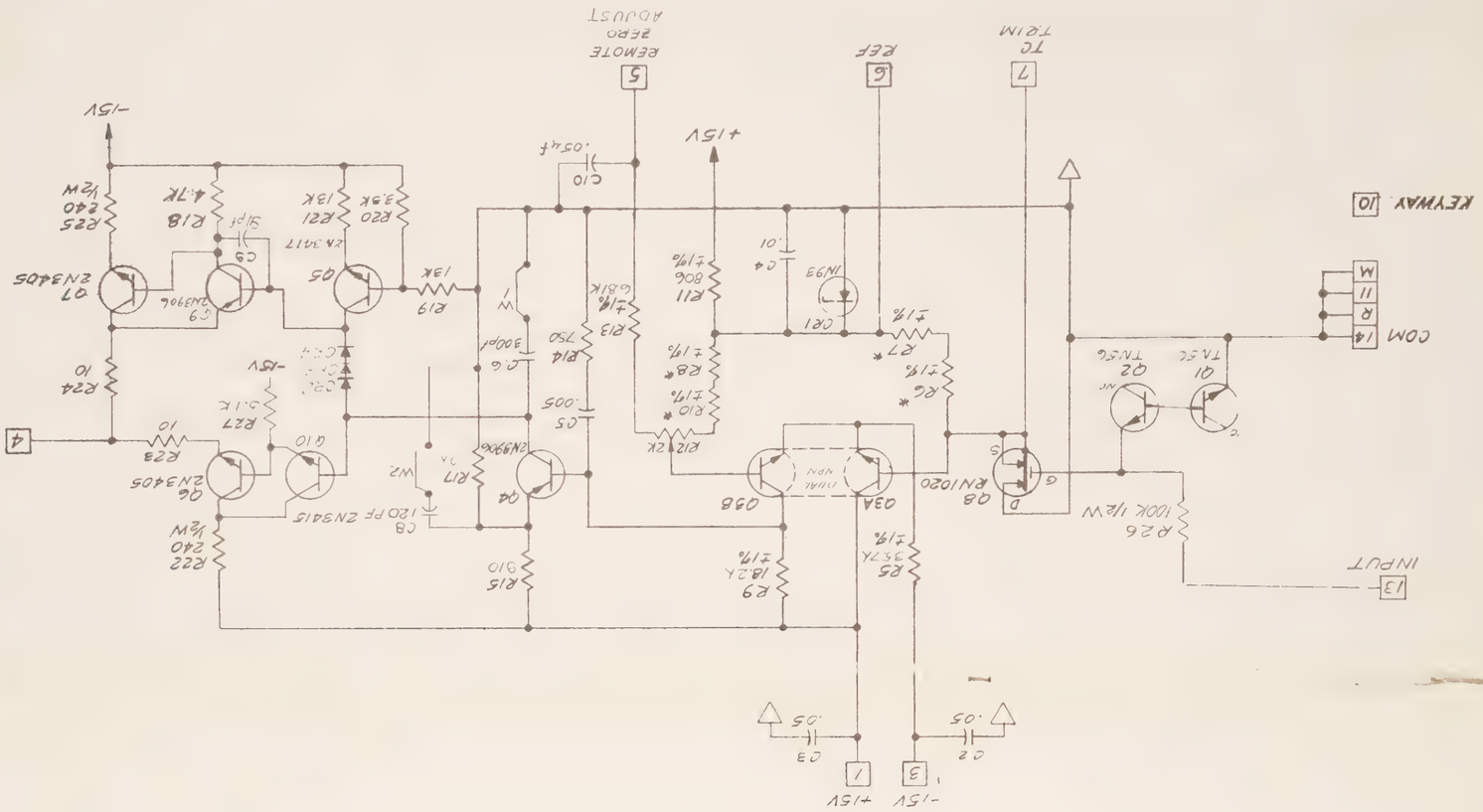

PR100
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
R 16
R 17
R 19
R 20
R 21
R 23
R 24
R 3
R 2
R 5
R 6
R 8
R 9
R 11
R 12
R 14
R 15
R 36
R 1
R 4
R 7
R 10
R 13
W 1
W 2
W 3
W 4
W 5
W 6
W 7
W 8
W 9
W 10
C 1
C 2
C 3
A

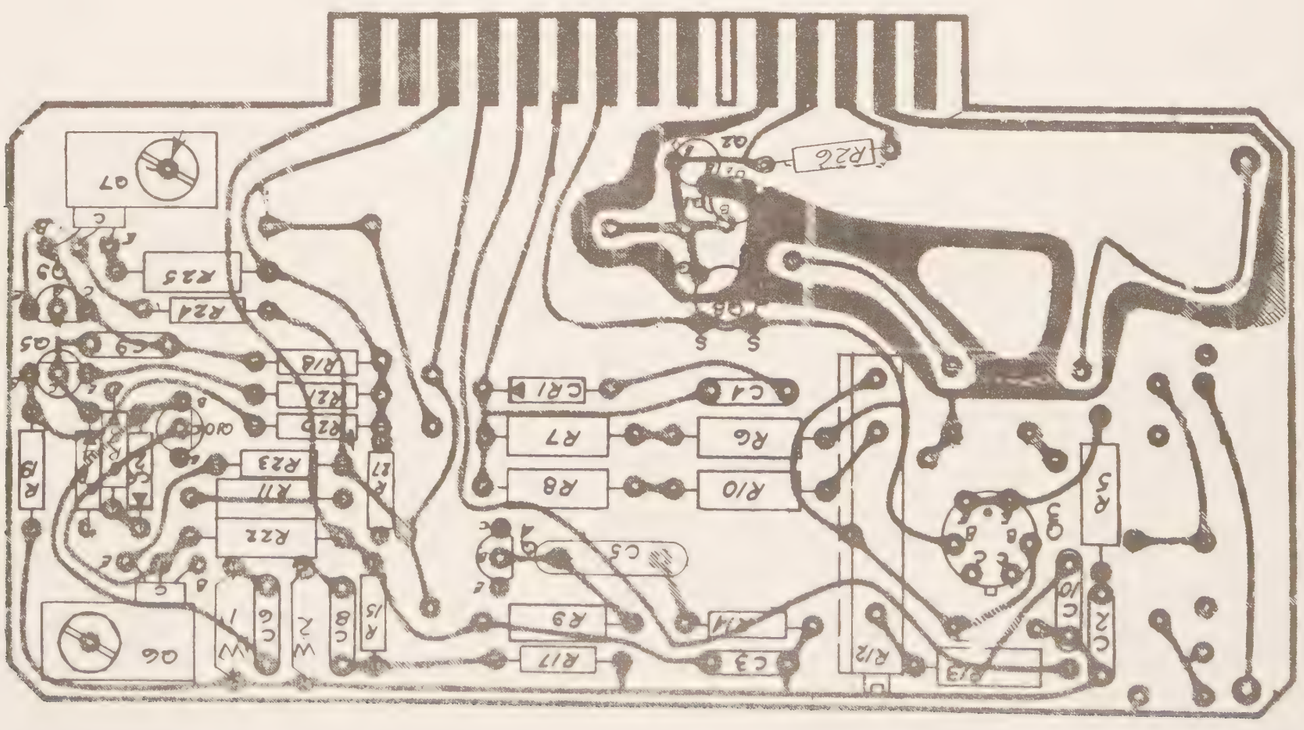


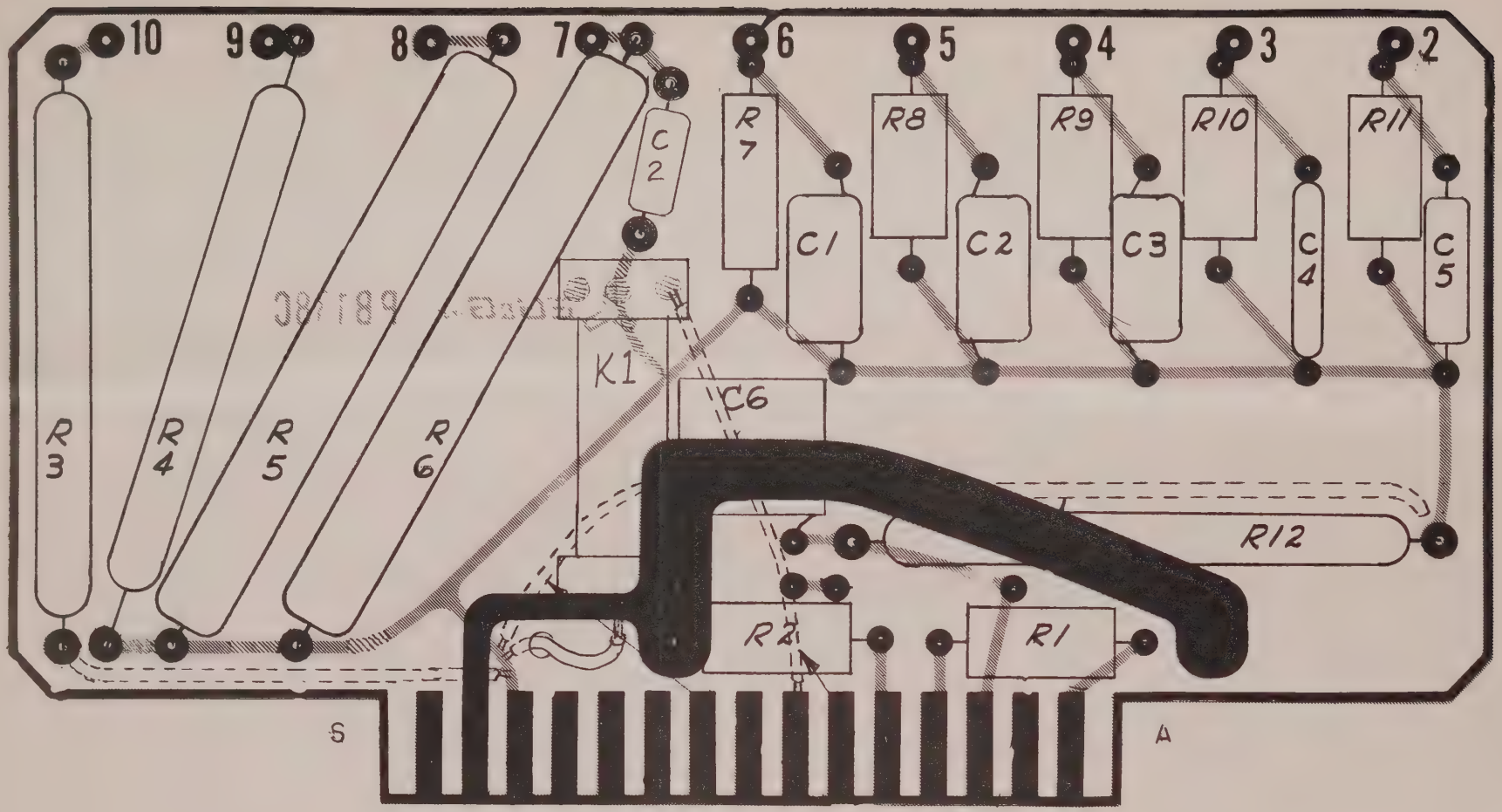
FWD-REV. DCU

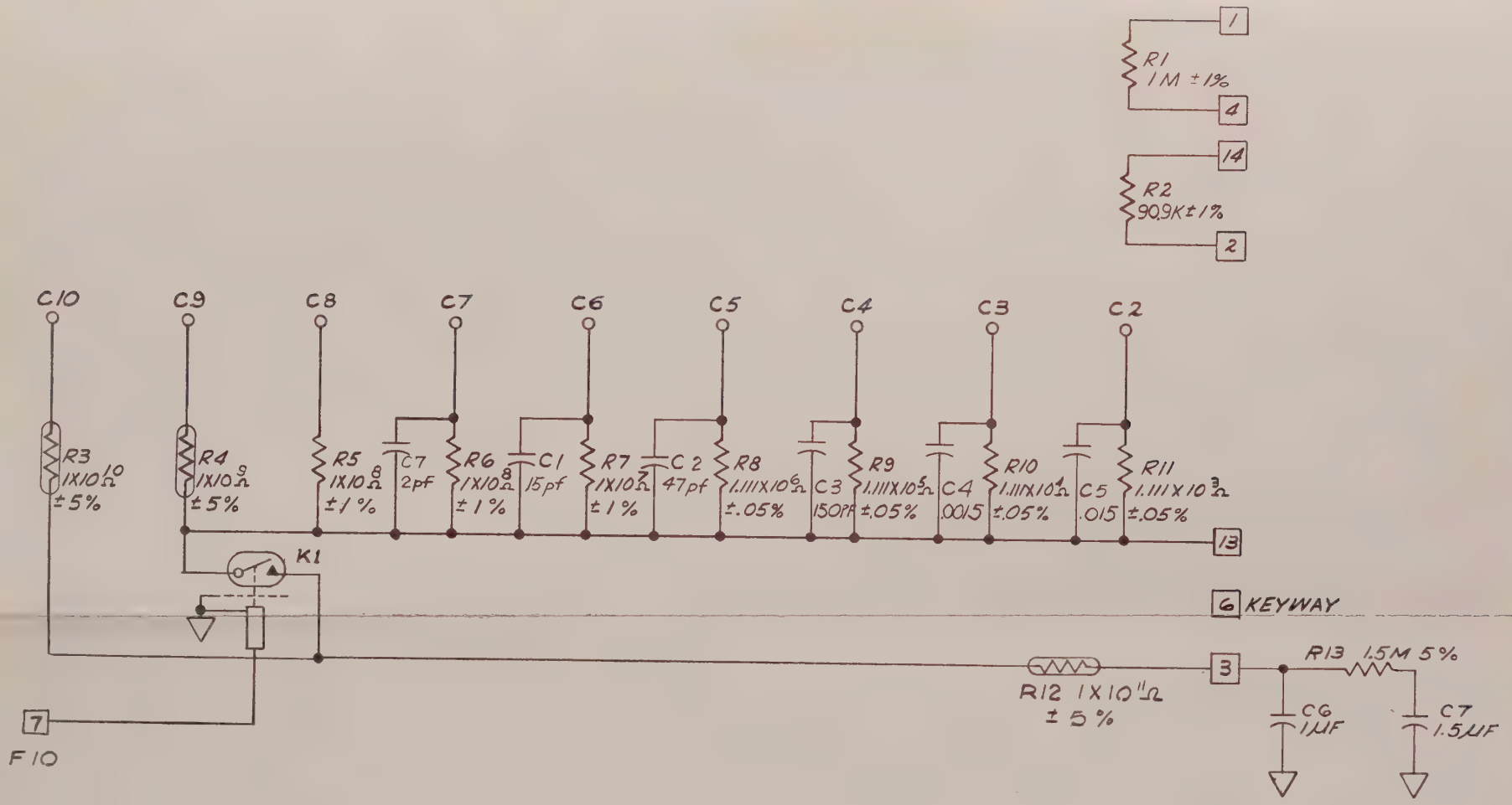



CUMULATIVE FEEDBACK FUNCTIONS +TRUE (BCD VARIABLES)
F2=1248
F3=248
F4=148+1248
F5=48
F6=128+48
F7=28+48
F8=48+128+18
F9=8
F10=124+8
F11=24+8
ENABLE
COIL COMMON
+TRUE BI-QUINARY
EVEN
2-3
4-5
6-7
8-9
KEY
COM

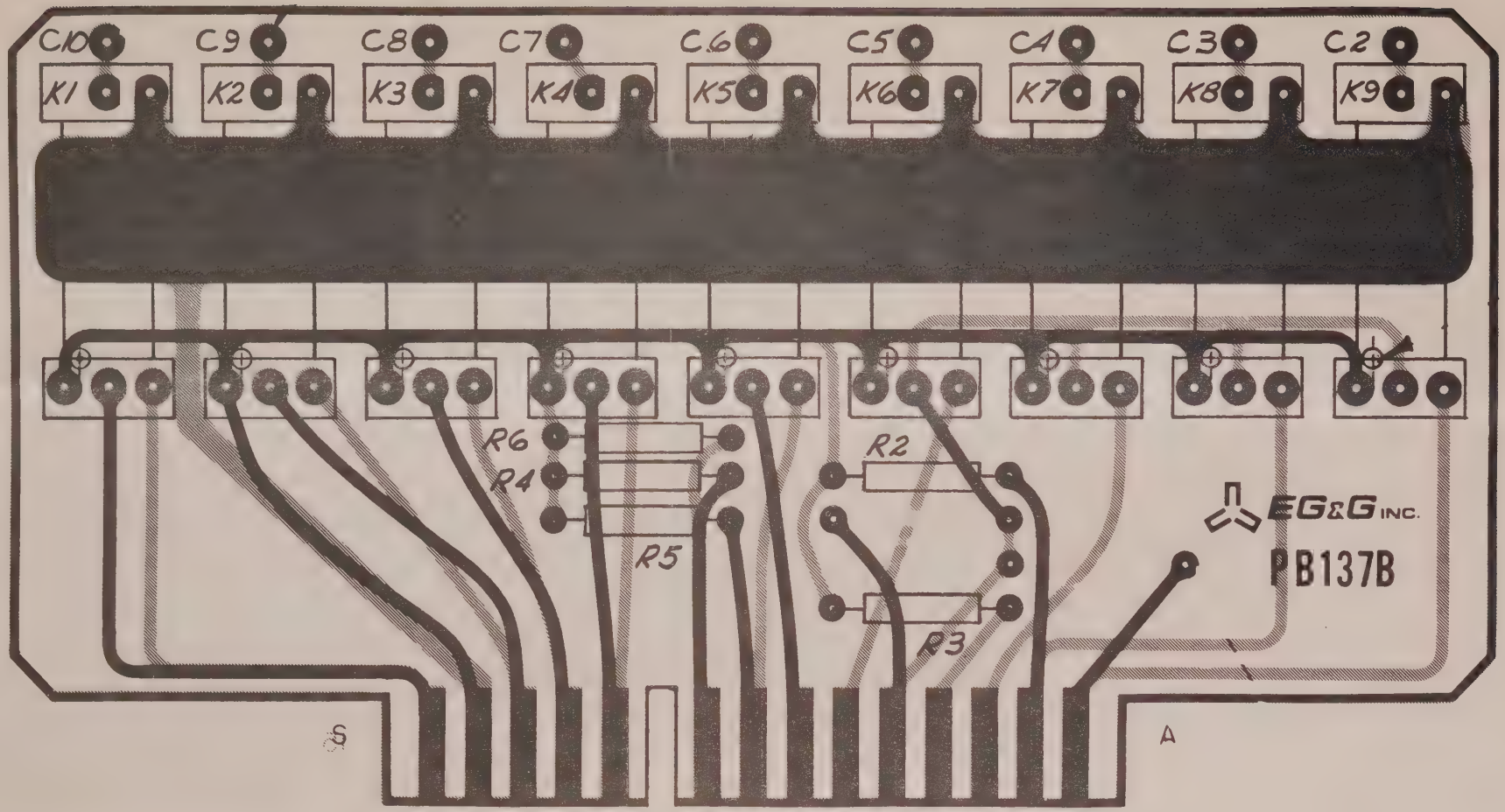

-15V
+15V
REMOTE ZERO ADJUST
REF
TC TRIM
KEYWAY
COM
INPUT
Q1 TA-52
Q2 TA-52
Q3A
Q3B
Q4
Q5
Q6 2N3405
Q7 2N3405
Q8 RN1020
CR1 IN93
R1 3.3K
R2 18.2K
R3 510
R4 100K 1/2W
R5 35.7K
R6
R7
R8
R9 18.2K
R10
R11 806
R12 2K
R13 750
R14 750
R15 510
R17 6.8K
R18 4.7K
R19 13K
R20 3.3K
R21 13K
R22 240 1/2W
R23 5.1K
R24 10
R25 240 1/2W
R26 100K 1/2W
R27
C1 .01
C2 .05
C3 .05
C4 .01
C5 .005
C6 300pf
C7 120PF 2N918
C8 120PF 2N918
C9 2N3906
C10 .05µf


Q1
Q2
Q3
Q4
Q5
Q6
Q7
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
R24
R25
C1
C2
C3
C4
C5
C6
C7
C8
C9
CR1

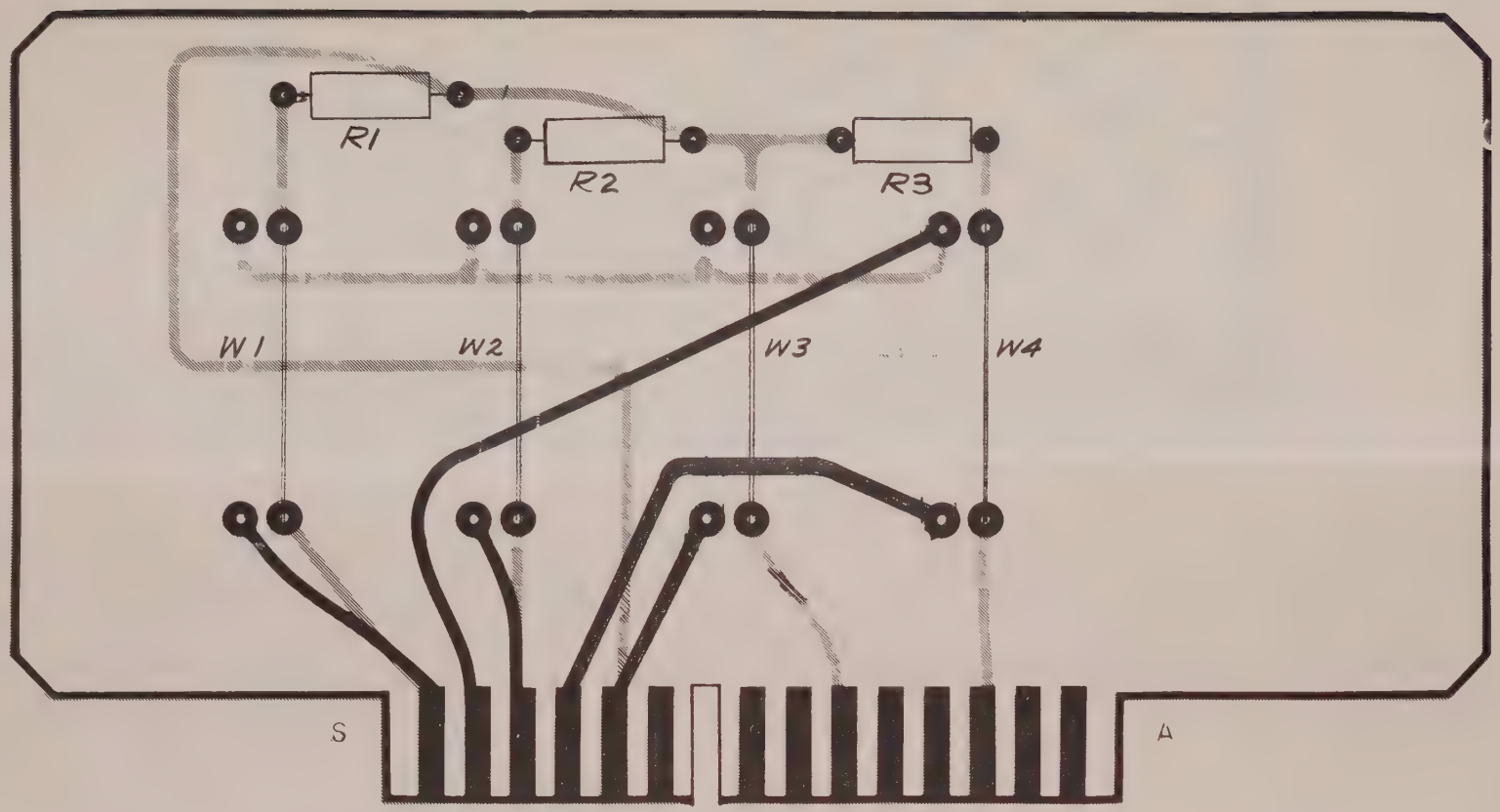

10
9
8
7
6
5
4
3
2
R3
R4
R5
R6
C2
R7
C1
R8
C2
R9
C3
R10
C4
R11
C5
K1
C6
R12
R2
R1
S
A

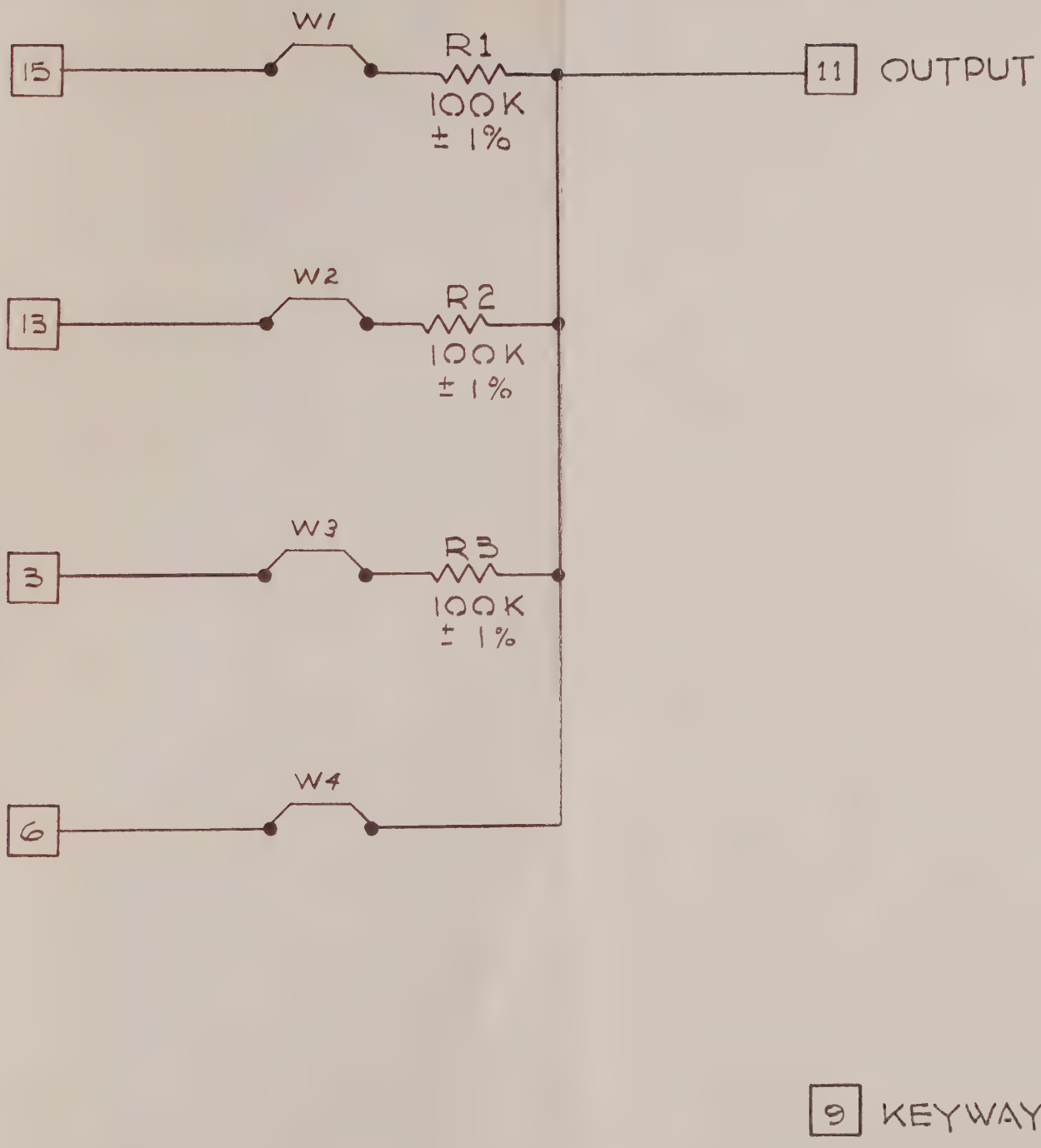

1
R1
1M ±1%
4
14
R2
90.9K±1%
2
C10
C9
C8
C7
C6
C5
C4
C3
C2
R3
1X10^10Ω
±5%
R4
1X10^9Ω
±5%
R5
1X10^8Ω
±1%
C7
2pf
R6
1X10^8Ω
±1%
C1
15pf
R7
1X10^7Ω
±1%
C2
47pf
R8
1.111X10^6Ω
±.05%
C3
150PF
±.05%
R9
1.111X10^5Ω
C4
.0015
±.05%
R10
1.111X10^4Ω
C5
.015
±.05%
R11
1.111X10^3Ω
±.05%
13
K1
6
KEYWAY
3
R13 1.5M 5%
R12 1X10^11Ω
±5%
C6
1μF
C7
1.5μF
7
F10

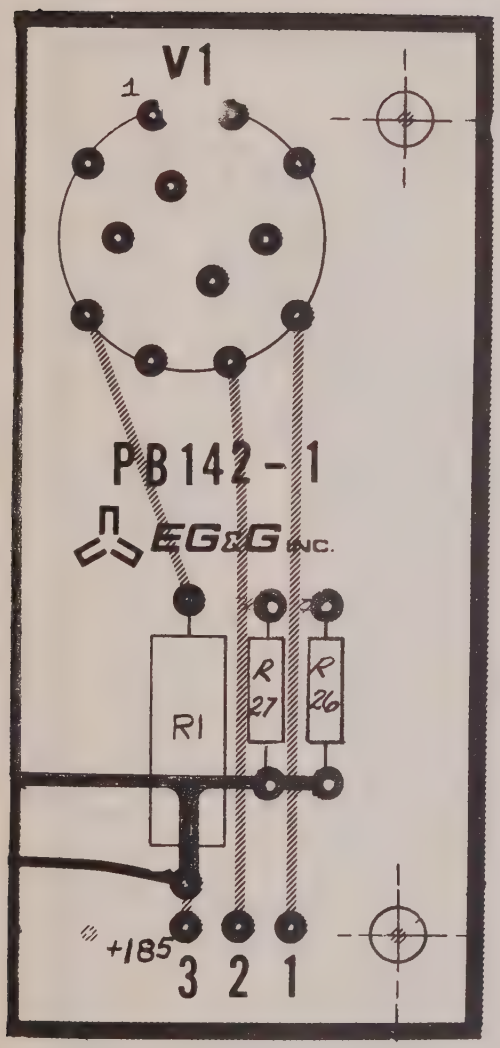
FEEDBACK C

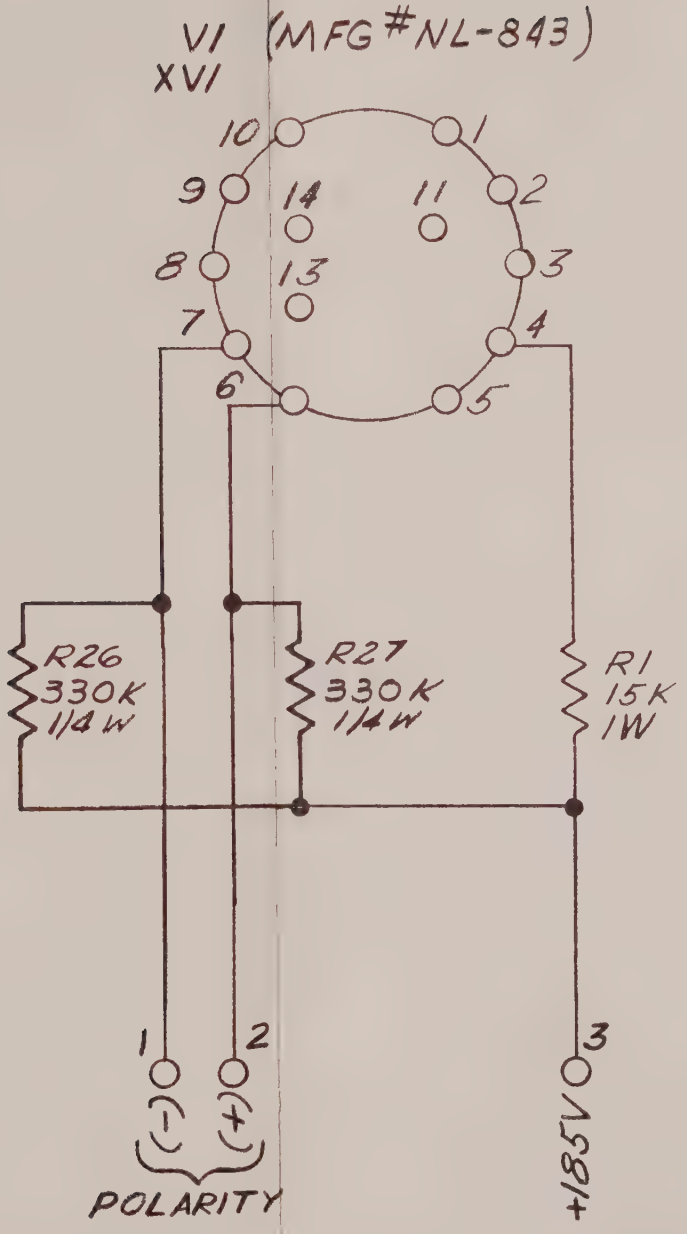

C10
C9
C8
C7
C6
C5
C4
C3
C2
K1
K2
K3
K4
K5
K6
K7
K8
K9
R6
R4
R5
R2
R3
EG&G INC.
PB137B
S
A

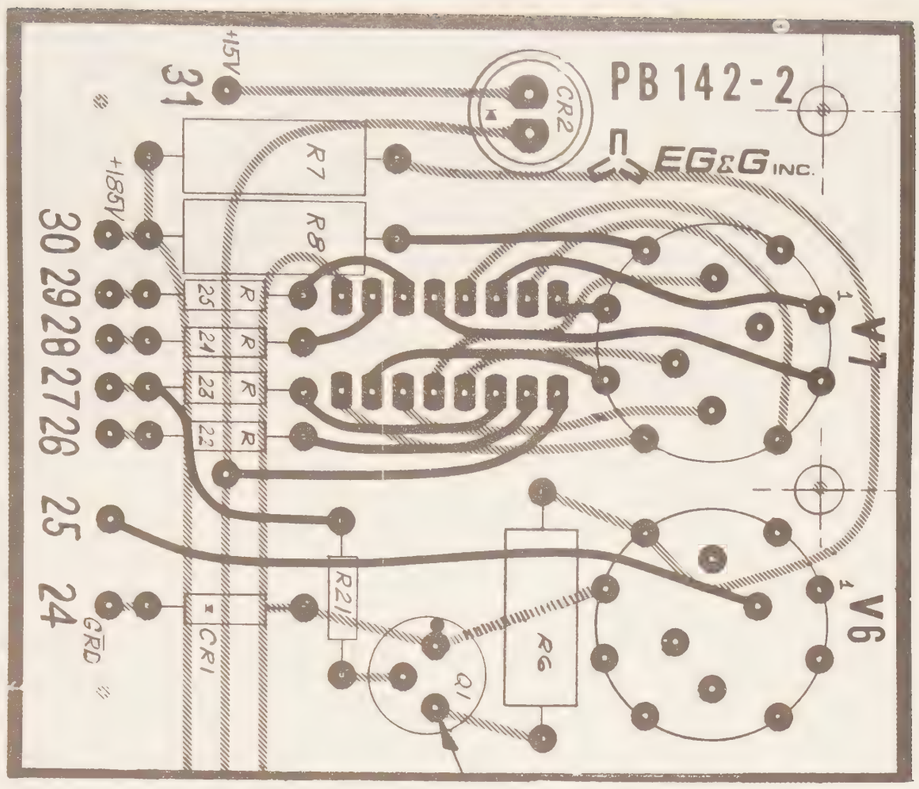
R
S
P
N
M
H
9
T
K
4
B
5
R2 10K ±1%
R3 10K ±1%
R4 9.09K ±1%
R5 9.09K ±1%
R6 9.09K ±1%
K1
K2
K3
K4
K5
K6
K7
K8
K9
C10
C9
C8
C7
C6
C5
C4
C3
C2
15 F10
13 F9
12 F8
11 F7
8 F6
6 F5
3 F4
2 F3
1 F2
14
10 KEYWAY

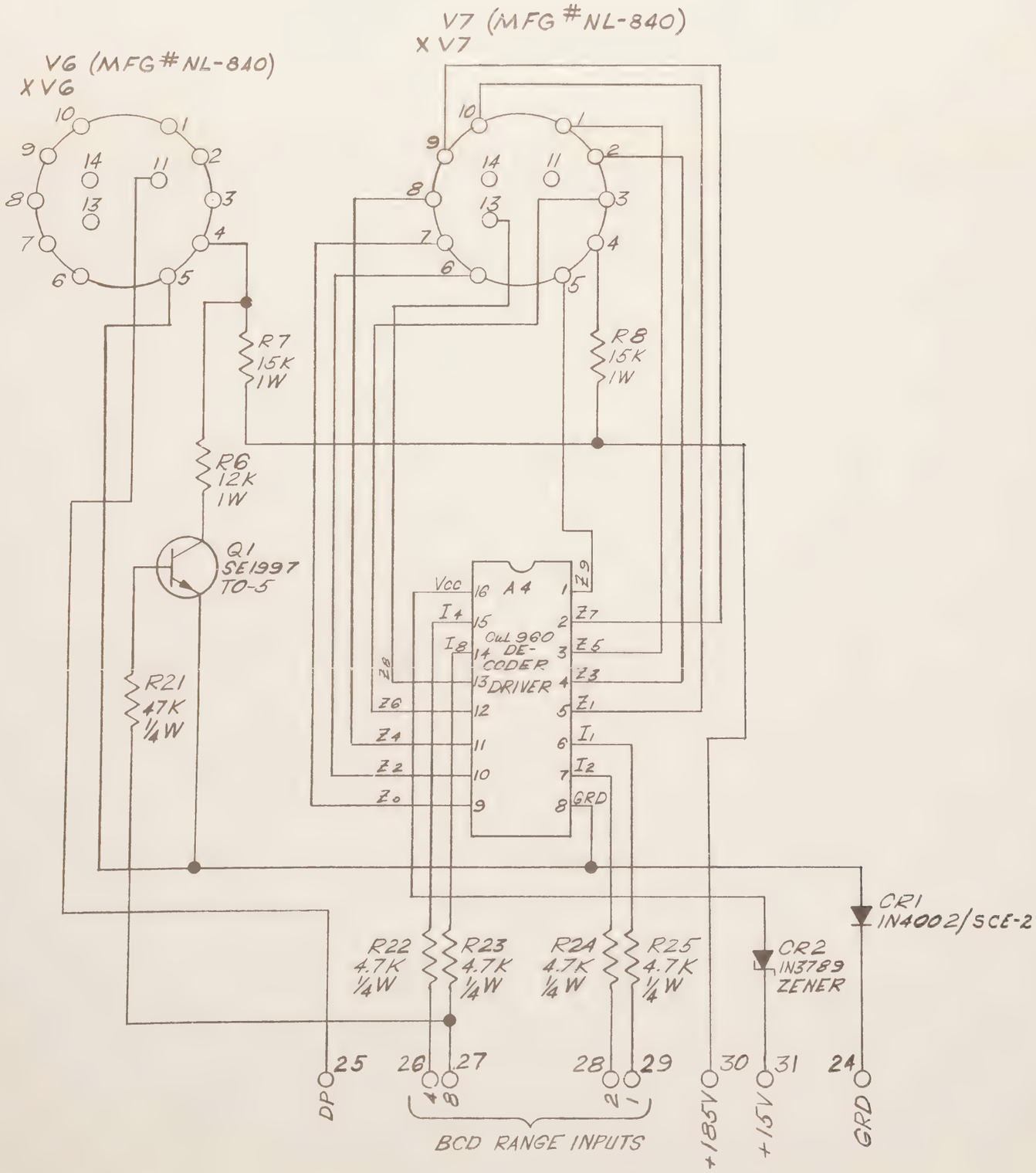

R1
R2
R3
W1
W2
W3
W4
S
A


W1
R1
100K
± 1%
15
11
OUTPUT
W2
R2
100K
± 1%
13
W3
R3
100K
± 1%
3
W4
6
9
KEYWAY

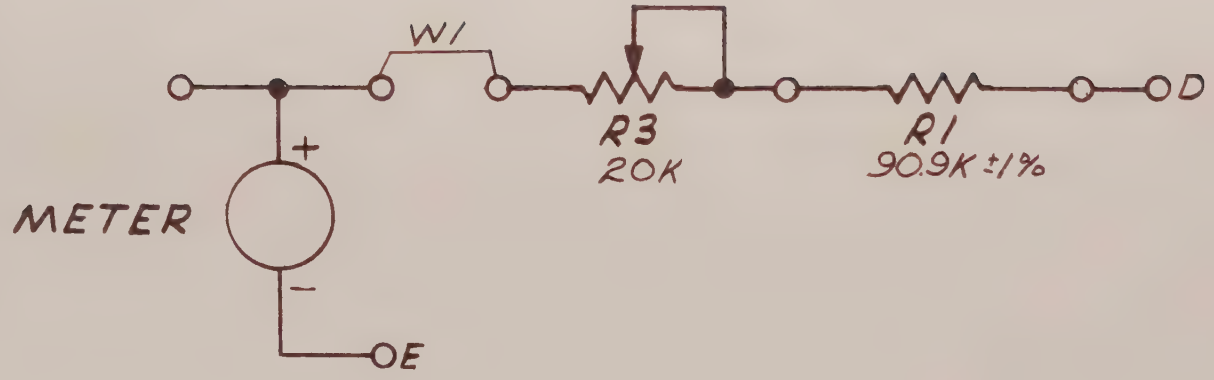

V1
1
PB142-1
EG&G INC.
R1
R 27
R 26
+185
3 2 1

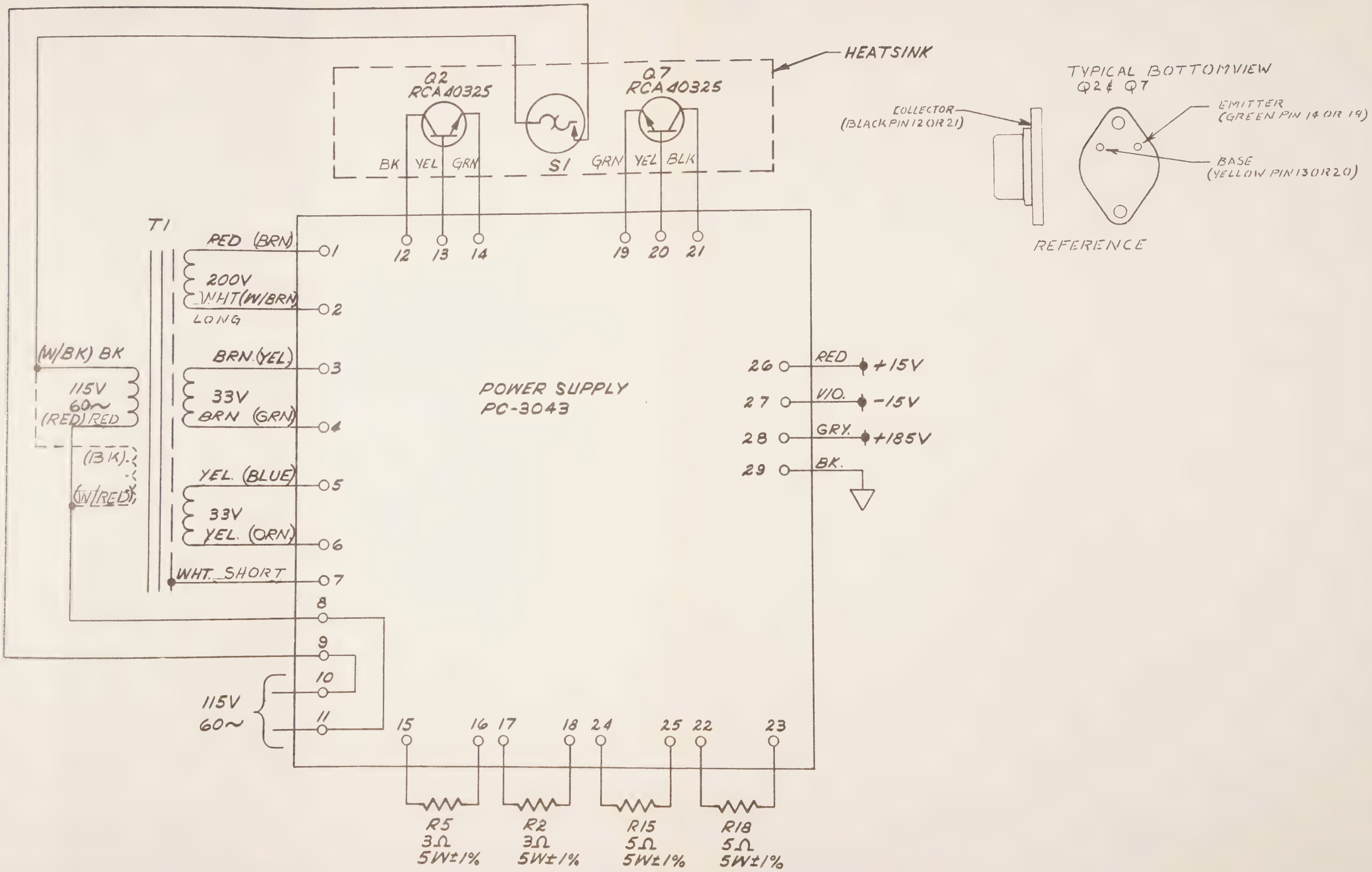

VI (MFG #NL-843)
XVI
10
1
9
14
11
2
8
13
3
7
4
6
5
R26
330K
1/4W
R27
330K
1/4W
R1
15K
1W
1
2
3
(-)
(+)
POLARITY
+185V


PB 142-2
EG&G INC.
+15V
31
+185V
30 29 28 27 26 25 24
GRD
CR2
R7
R8
R
23
21
23
22
CR1
R21
Q1
R6
V7
V6

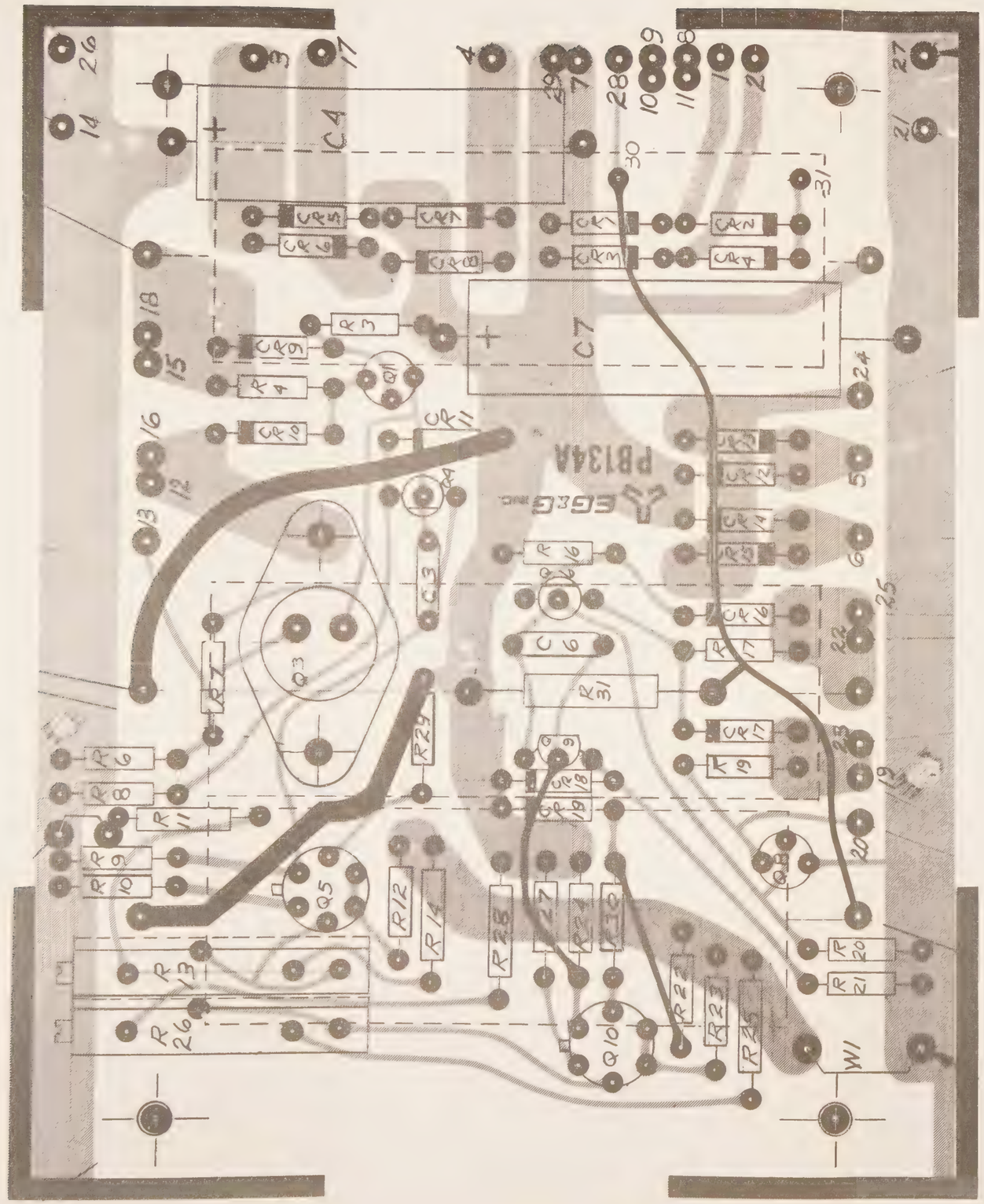

V7 (MFG # NL-840)
XV7
V6 (MFG # NL-840)
XV6
R7 15K 1W
R8 15K 1W
R6 12K 1W
Q1 SE1997 TO-5
R21 47K 1/4W
Vcc
A4
OWL 960 DE-CODER DRIVER
I4
I8
Z8
Z6
Z4
Z2
Z0
Z9
Z7
Z5
Z3
Z1
I1
I2
GRD
R22 4.7K 1/4W
R23 4.7K 1/4W
R24 4.7K 1/4W
R25 4.7K 1/4W
CR1 IN4002/SCE-2
CR2 IN3789 ZENER
DP
BCD RANGE INPUTS
+185V
+15V
GRD

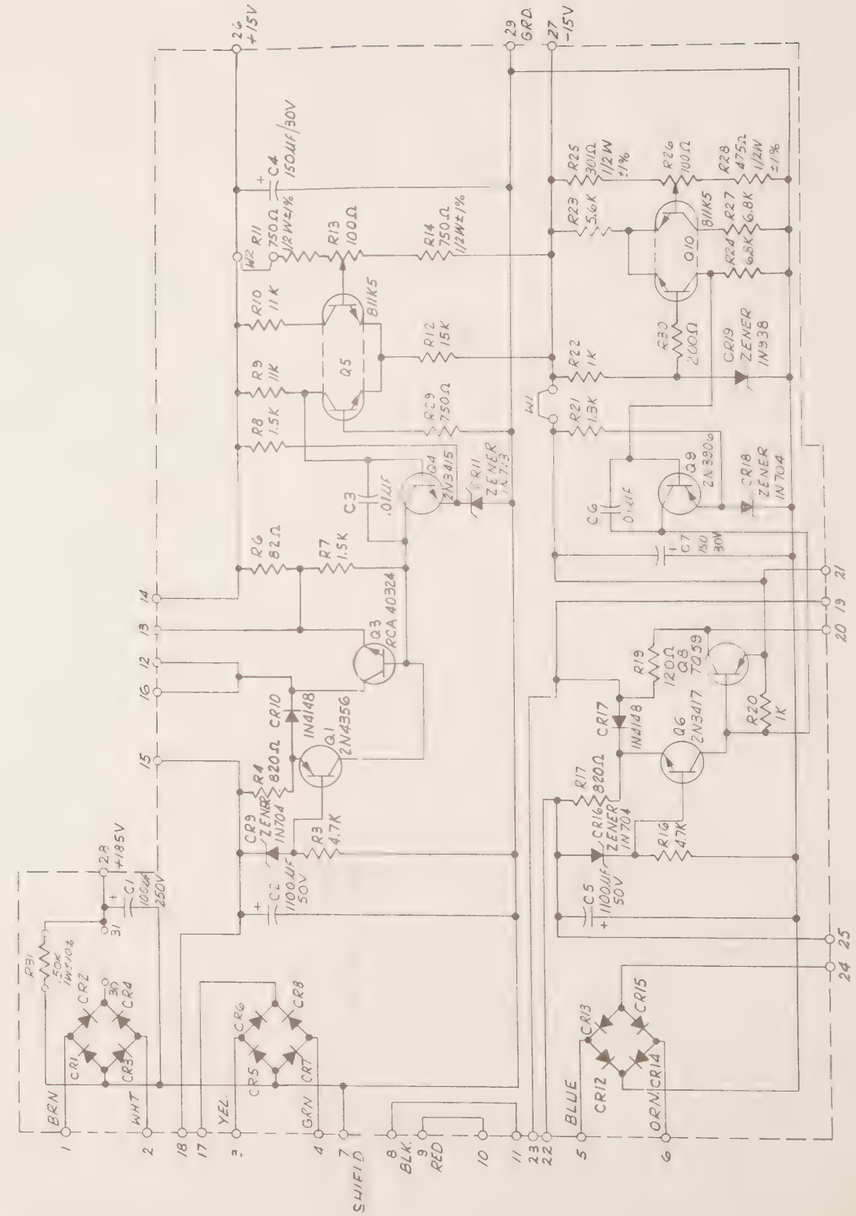
A
W1
B
(Y)
(X)
E
R1
D
R
3


W1
R3
20K
R1
90.9K ±1%
D
METER
+
−
E

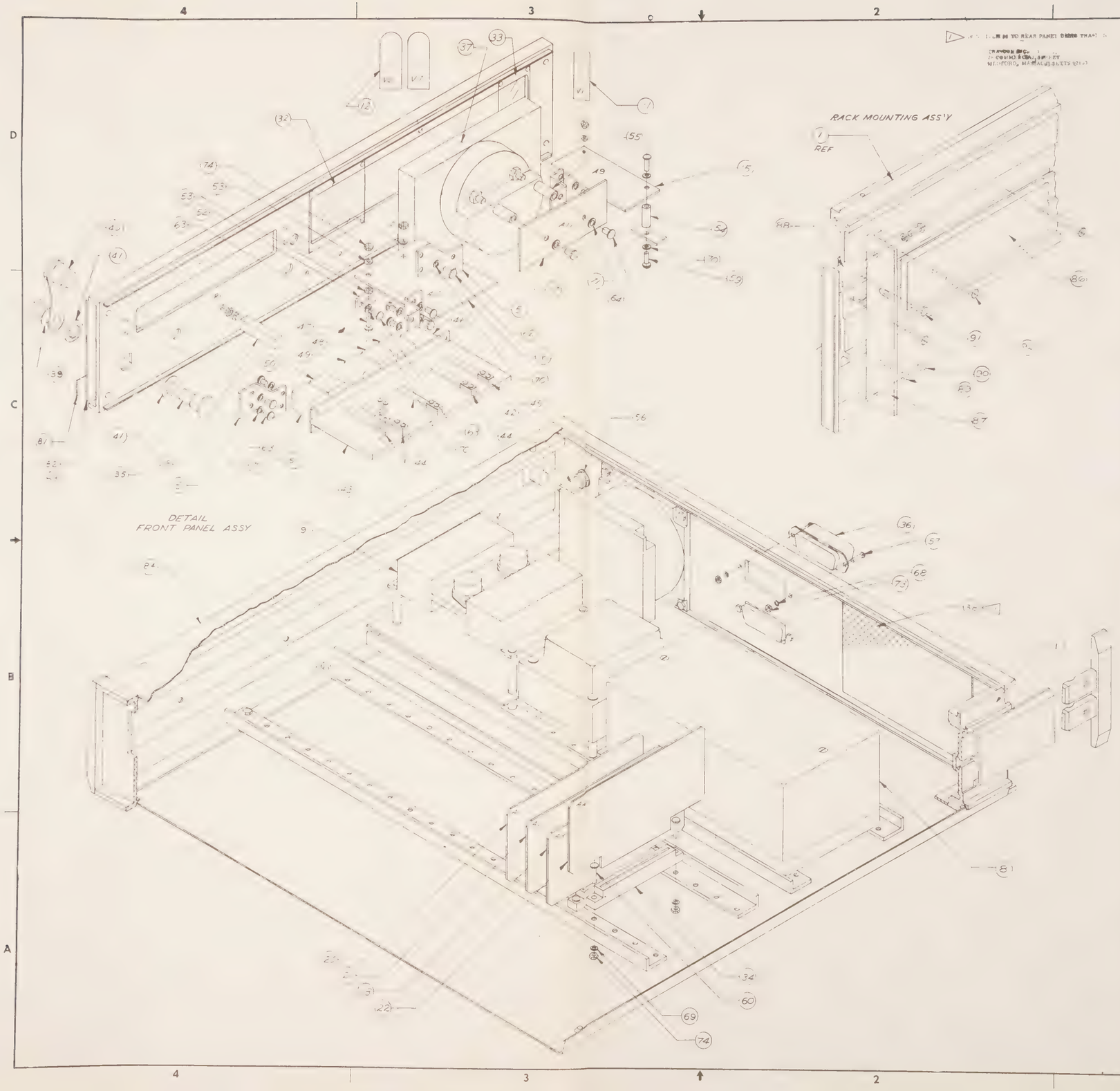


SCHEMATIC DIAGRAM POWER SUPPLY





POWER SUPPLY REGULATOR



ISS	DESCRIPTION	DRAFT	CHECK	ENGR
-	ORIGINAL ISSUE	[illegible] 5-7-62	[illegible] 5-7-62	[illegible] 5-7-62
A	ASSEMBLED FEEDBACK	[illegible] 8-30-62	[illegible]	[illegible]
B	NOMICLATOR REVISION	[illegible] 12-6-62	[illegible]	[illegible]

8		SCREW, 100° FLAT HD #10-32 NF X 1		91
12		SCREW, FLAT HD #8-32 NC X 1/2		91
4		SCREW, BIND HD #8-32 NC X 3/8		90
4		WASHER, LOCK #8		89
2	240-0002	HANDLE		88
2	250-0613	FLANGE, MTG	PC-4128	87
2	250-0618	ADAPTER, RACK MTG.	PC-4173	86

RACK MTG ONLY

REF	250-0627	PANEL FALSE NOMENCLATURE	PD-4284	
REF	250-0614	PANEL FALSE NOMENCLATURE	PD-4285	
REF	240-0027	INST. BAIL		85
2	250-0613	COVER	PD-4088	84
REF	250-0614	PANEL, FALSE (REAR INPUT) OPT.	PD-4253	83
REF	250-0621	PANEL, FALSE (FRONT INPUT)	PD-4092	82
1	250-5001	STRIP, NOMENCLATURE	PC-4164	81

AR		WIRE TEFLON, #22 STRANDED		80
AR		WIRE, BUSS, #22 COPPER TINNED		79
AR	600-0001	CABLE, COAXIAL		78
				77
				76
				75
		NUT, HEX HD, #4-40 NC		74
4		NUT, HEX HD, #2-56 NC		73
				72
		WASHER, LOCK #10		71
		WASHER, LOCK #6		70
		WASHER, LOCK #4		69
		WASHER, LOCK #2		68
				67
				66
		SCREW, BIND HD, #10-32 NF x 1/4		65
		SCREW, BIND HD #6-32 NC x 3/16		64
		SCREW, BIND HD, #6-32 NC x 5/32		63
6		SCREW, BIND HD, #4-40 NC x 1/2		62
9		SCREW, BIND HD, #4-40 NC x 3/8		61
4		SCREW, BIND HD, #2-56 NC x 5/16		60
1	510-1601	HOLDER FUSE		59
2	280-0721	SPACER #10-32 NF x 5/8		58
1	280-0720	SPACER #4-40 NC x 5/8		57
6	280-0406	[illegible] FIBER #4		56
3	140-0015	BRACKET ANGLE .032 x 1/2		55
1	510-0617	BUTTON, PUSH (DEC)	PA 4.01	54
1	510-0616	BUTTON, PUSH (INC)	PA 4200	53
1	510-0615	BUTTON, PUSH (REM)	PA 4199	52
1	510-0614	BUTTON, PUSH (AUTO)	PA 4198	51
1	510-0613	BUTTON, PUSH (MAN)	PA 4197	50
1	510-0612	BUTTON, PUSH OFF	PA 4196	49
4	510-0604	CONTACT, SWITCH (N.C.)		48
4	510-0603	CONTACT, SWITCH (N.O.)		47
1	510-0608	SWITCH	S1	46
1	515-1101	FUSE, (1/2 AMP)	F1	45
1	280-0404	INSULATOR		44
4	210-0412	[illegible] BNC		43
4	280-1326	WASHER, FLAT 1/4 I.D. x .063 THK		42
1	250-0603	GRILL	PC-4104	41
1	290-0003	METER	M1	40
1	210-0505	CONNECTOR [illegible] RIBBON	J354	39
1	210-0512	CONNECTOR, BNC	J1	38
4	210-1002	CONNECTOR FC		37
1	250-0616	LENS, POLARITY DIS.	PC-4097	36
1	250-0617	LENS, RANGE DIS.	PC-4098	35
1	470-0805	RESISTOR 6.2K, 1W ±10%	R8	34
				33
				32
1	470-5328	POTENTIOMETER 200Ω	R1	31
				30
				29
				28
				27
				26
				25
				24
				23
	700-0031	DECODER DRIVER A1	PC-3000	22
1	700-0032	RANGE CONTROL A2	PC-3001	21
1	700-0041	ABSOLUTE VALUE A1	PC-3082	20
				19
	700-0060	FWD-REV DCU A3	PC-3078	18
1	700-0101	METER BOARD	PC-3154	17

PE-1033-B

1	700-0095B	RANGE DISPLAY	PC-3045	16
1	700-0095A	POLARITY DISPLAY	PC-3044	15
				14
2	570-1005	READOUT TUBE NL-840	V2 V3	13
1	570-1003	READOUT TUBE NL-843	V1	12
				11
REF	700-0201	POWER SUPPLY	PC-1023	10
REF	700-0226	FEEDBACK ASSY.	PC-1052	9
				8
				7
4	230-0608	BRACKET, PANEL	PC 4124A	6
				5
REF		SCHEMATIC DIAGRAM	PD-2058	4
REF		BLOCK DIAGRAM	PD-2057	3
1	PE-1025	CHASSIS (3-1/2)	1	2
QTY.	PART NO.	DESCRIPTION	REF. DES.	ITEM

LIST OF MATERIAL

EG&G INC. — COMMERCIAL INSTRUMENTATION
P.O. BOX 1912 LAS VEGAS NEVADA
BOSTON MASS. — LAS VEGAS NEVADA
ALBUQUERQUE N.M. — SANTA BARBARA, CALIF

PICOAMMETER
(929)

FINAL	UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES	ULRICH WILLIE DEC 1967	DO NOT SCALE THIS DRAWING	PE-1033-B SCALE 1 SHEET 1 OF 1
NEXT ASSY				

SECTION VII - REPLACEABLE PARTS

7.1 This section contains information for ordering replacement parts. Following are parts lists in alpha-numeric order of their reference designations and and indicating the description and EG&G part number of each part together with any applicable notes.

7.2 Ordering Information

To obtain replacement parts, address order or inquiry to EG&G, Inc., Commercial Instrumentation Department, P. O. Box 1912, Las Vegas, Nevada 89101.

7.3 Non-Listed Parts

To obtain parts not listed, include:

a. Instrument Model Number
b. Instrument Serial Number
c. Description of the Part
d. Function and Location of Part.

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1	470-1031	Res. 1/4W ±5% 5.1K	
R2	470-1047	Res. 1/4W ±5% 33K	
R3	470-1057	Res. 1/4W ±5% 150K	
R4	470-1031	Res. 1/4W ±5% 5.1K	
R5	470-1003	Res. 1/4W ±5% 200	
R6	470-1054	Res. 1/4W ±5% 82K	
R7	470-1025	Res. 1/4W ±5% 2.2K	
R8,9	470-0004	Res. 1/4W ±5% 22K	
R10,11	470-1017	Res. 1/4W ±5% 1K	
R12	470-1047	Res. 1/4W ±5% 33K	
R13	470-1419	Res. 1/4W ±.01% 25K W.W.	
R14	470-1043	Res. 1/4W ±5% 20K	
R15	470-1018	Res. 1/4W ±5% 1.1K	
R16	470-1010	Res. 1/4W ±5% 430	
R17	470-1036	Res. 1/4W ±5% 10K	
R18	470-5324	Pot. 10K	
R19	470-1036	Res. 1/4W ±5% 10K	
R20	470-1024	Res. 1/4W ±5% 2K	
R21	470-1039	Res. 1/4W ±5% 13K	
R22	470-1013	Res. 1/4W ±5% 680	
R23	470-0401	Res. 1/2W ±5% 75	
R24	470-1053	Res. 1/4W ±5% 75K	
R25	470-1038	Res. 1/4W ±5% 12K	
R26	470-1008	Res. 1/4W ±5% 330	
R27	470-1058	Res. 1/4W ±5% 240K	
R28		Not Used	
R29	470-1419	Res. 1/4W ±.01% 25K W.W.	
R30	470-1030	Res. 1/4W ±5% 4.7K	
C1	150-0109	Cap. Elect. 15µf 15v	
C2	150-0021	Cap. Cer. Disc 91pf	
C3	150-0027	Cap. Cer. Disc .005µf	
C4	150-0002	Cap. Mono. Cer. 1.0µf	
CR1-5	480-1101	Diode 1N4148	
CR6	480-1004	Diode 1N482	
K1	450-0009	Reed Relay Compac Hollister Mfg. #15-1C-12	
Q1	480-6002	Transistor Dual NPN	
Q2	480-5802	Transistor 2N3638A	
Q3	480-5303	Transistor 2N3415	
Q4,5	480-5304	Transistor 2N3877A	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
Q6	480-6002	Transistor Dual NPN	
Q7	480-5805	Transistor 2N3906	
Q8	480-5802	Transistor 2N3638A	
Q9	480-5308	Transistor 2N3405	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1	470-1024	Res. 1/4W ±5% 2K	
R2	470-1045	Res. 1/4W ±5% 27K	
R3	470-5325	Pot. Beckman #78P 20K	
R4	470-1043	Res. 1/4W ±5% 20K	
R5	470-1055	Res. 1/4W ±5% 100K	
R6	470-1043	Res. 1/4W ±5% 20K	
R7	470-1045	Res. 1/4W ±5% 27K	
R8	470-5324	Pot. Beckman #78P 10K	
R9	470-1045	Res. 1/4W ±5% 27K	
R10	470-1055	Res. 1/4W ±5% 100K	
R11,12	470-1031	Res. 1/4W ±5% 5.1K	
R13,14	470-1041	Res. 1/4W ±5% 16K	
R15	470-1026	Res. 1/4W ±5% 2.4K	
R16	470-1025	Res. 1/4W ±5% 2.2K	
R17	470-1004	Res. 1/4W ±5% 220	
R18	470-1043	Res. 1/4W ±5% 5.1K	
R19	470-1051	Res. 1/4W ±5% 51K	
R20	470-1028	Res. 1/4W ±5% 3.3K	
R21	470-1040	Res. 1/4W ±5% 15K	
R22	470-1015	Res. 1/4W ±5% 820	
R23	470-1004	Res. 1/4W ±5% 220	
R24	470-1043	Res. 1/4W ±5% 5.1K	
R25	470-1051	Res. 1/4W ±5% 51K	
R26	470-1028	Res. 1/4W ±5% 3.3K	
R27	470-1041	Res. 1/4W ±5% 15K	
R28	470-1015	Res. 1/4W ±5% 820	
R29	470-1041	Res. 1/4W ±5% 15K	
R30	470-1017	Res. 1/4W ±5% 1K	
R31,32	470-1040	Res. 1/4W ±5% 15K	
R33	470-1017	Res. 1/4W ±5% 1K	
R34	470-1040	Res. 1/4W ±5% 15K	
R35	470-0010	Res. 1/4W +5% 470	
R36-39	470-1031	Res. 1/4W ±5% 5.1K	
R40	470-1036	Res. 1/4W ±5% 10K	
R41-45	470-1031	Res. 1/4W ±5% 5.1K	
R46	470-1036	Res. 1/4W ±5% 10K	
R47	470-1031	Res. 1/4W ±5% 5.1K	
C1,2	150-0007	Cap. Mono. .68µf	
C3,4	150-0101	Cap. Elect. 5µf 25v	
C5-7	150-0012	Cap. Cer. Disc .05µf	
C8,9	150-0024	Cap. Cer. Disc 300pf	
C10,11	150-0012	Cap. Cer. Disc .05µf	
C12	150-0005	Cap. Mono 0.1µf	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
C13,14	150-0012	Cap. Cer. Disc .05μf	
C15	150-0005	Cap. Mono. 0.1μf	
C16	150-0012	Cap. Cer. Disc .05μf	
CR1-26	480-1101	Diode 1N4148	
Q1	480-5805	Transistor 2N3906	
Q2-4	480-5303	Transistor 2N3415	
Q5-12	480-5803	Transistor 2N3646	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1	470-1004	Res. 1/4W ±5% 220	
R2,3	470-1019	Res. 1/4W ±5% 1.2K	
R4,5	470-1036	Res. 1/4W ±5% 10K	
R6,7	470-1039	Res. 1/4W ±5% 13K	
R8	470-1030	Res. 1/4W ±5% 4.7K	
R9	470-1028	Res. 1/4W ±5% 3.3K	
R10,11	470-1027	Res. 1/4W ±5% 3K	
R12	470-1030	Res. 1/4W ±5% 4.7K	
R13	470-1028	Res. 1/4W ±5% 3.3K	
R14,15	470-1027	Res. 1/4W ±5% 3K	
R16	470-1041	Res. 1/4W ±5% 16K	
R17	470-1048	Res. 1/4W ±5% 36K	
R18	470-1041	Res. 1/4W ±5% 16K	
R19	470-1048	Res. 1/4W ±5% 36K	
R20	470-1041	Res. 1/4W ±5% 16K	
R21	470-1048	Res. 1/4W ±5% 36K	
R22	470-1041	Res. 1/4W ±5% 16K	
R23	470-1048	Res. 1/4W ±5% 36K	
R24-27	470-1028	Res. 1/4W ±5% 3.3K	
R28	470-1021	Res. 1/4W ±5% 1.5K	
R29,30	470-1039	Res. 1/4W ±5% 13K	
R31-34	470-1033	Res. 1/4W ±5% 6.2K	
R35	470-1021	Res. 1/4W ±5% 1.5K	
R36,37	470-1039	Res. 1/4W ±5% 13K	
R38-41	470-1033	Res. 1/4W ±5% 6.2K	
R42	470-1021	Res. 1/4W ±5% 1.5K	
R43,44	470-1039	Res. 1/4W ±5% 13K	
R45-48	470-1033	Res. 1/4W ±5% 6.2K	
R49	470-1021	Res. 1/4W ±5% 1.5K	
R50,51	470-1039	Res. 1/4W ±5% 13K	
R52-55	470-1033	Res. 1/4W ±5% 6.2K	
R56	470-1021	Res. 1/4W ±5% 1.5K	
R57,58	470-1039	Res. 1/4W ±5% 13K	
R59-62	470-1033	Res. 1/4W ±5% 6.2K	
R63,64	470-1024	Res. 1/4W ±5% 2K	
R65,66	470-1040	Res. 1/4W ±5% 15K	
R67,68		Not Used	
R69-73	470-1040	Res. 1/4W ±5% 15K	
R74	470-1016	Res. 1/4W ±5% 910	
R75,76	470-1049	Res. 1/4W ±5% 39K	
C1	150-0012	Cap. Cer. Disc .05μf	
C2-5	150-0019	Cap. Cer. Disc 30pf	
C6	150-0012	Cap. Cer. Disc .05μf	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
C7	150-0018	Cap. Cer. Disc 15pf	
C8,9	150-0019	Cap. Cer. Disc 30pf	
C10	150-0018	Cap. Cer. Disc 15pf	
C11-20	150-0013	Cap. Cer. Disc 68pf	
C21		Not Used	
C22	150-0012	Cap. Cer. Disc .05µf	
CR1-6, 9-20,22,23, 28,29,31-41,25 & 26	480-1101	Diode 1N4148	
Q1-11 & 15-18	480-5803	Transistor 2N3646	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1	470-1046	Res. 1/4W ±5% 30K	
R2	470-1031	Res. 1/4W ±5% 5.1K	
R3	470-1054	Res. 1/4W ±5% 82K	
R4	470-1046	Res. 1/4W ±5% 30K	
R5	470-1031	Res. 1/4W ±5% 5.1K	
R6	470-1054	Res. 1/4W ±5% 82K	
R7	470-1046	Res. 1/4W ±5% 30K	
R8	470-1031	Res. 1/4W ±5% 5.1K	
R9	470-1054	Res. 1/4W ±5% 82K	
R10	470-1046	Res. 1/4W ±5% 30K	
R11	470-1031	Res. 1/4W ±5% 5.1K	
R12	470-1054	Res. 1/4W ±5% 82K	
R13	470-1046	Res. 1/4W ±5% 30K	
R14	470-1031	Res. 1/4W ±5% 5.1K	
R15	470-1054	Res. 1/4W ±5% 82K	
R16-25	470-1040	Res. 1/4W ±5% 15K	
R26-35		Not Used	
R36	470-1001	Res. 1/4W ±5% 10	
C1-3	150-0012	Cap. Cer. Disc .05μf	
CR1-62	480-1101	Diode 1N4148	
Q1-15	480-5303	Transistor 2N3415	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1-4		Not Used	
R5	470-2127	Res. 1/4W ±1% 35.7K	
R6-8		Res. Factory Adjusted	
R9	470-2125	Res. 1/4W ±1% 18.2K	
R10		Res. Factory Adjusted	
R11	470-2002	Res. 1/4W ±1% 806	
R12	470-5322	Pot. 2K	
R13	470-2104	Res. 1/4W ±1% 6.81K	
R14	470-1014	Res. 1/4W ±5% 750	
R15	470-0010	Res. 1/4W ±5% 910	
R16		Not Used	
R17	470-1036	Res. 1/4W ±5% 10K	
R18	470-1031	Res. 1/4W ±5% 4.7K	
R19	470-1039	Res. 1/4W ±5% 13K	
R20	470-1028	Res. 1/4W ±5% 3.3K	
R21	470-1039	Res. 1/4W ±5% 13K	
R22	470-0403	Res. 1/2W ±5% 240	
R23,24	470-1001	Res. 1/4W ±5% 10	
R25	470-0203	Res. 1/2W ±5% 240	
R26	470-0405	Res. 1/2W ±5% 1.5K	
R27	470-1031	Res. 1/4W ±5% 5.1K	
C1		Not Used	
C2,3	150-0012	Cap. Cer. Disc .05µf	
C4	150-0026	Cap. Cer. Disc .01µf	
C5	150-0027	Cap. Cer. Disc .005µf	
C6	150-0024	Cap. Cer. Disc 300pf	
C7		Not Used	
C8	150-0009	Cap. Cer. Disc 120pf	
C9	150-0021	Cap. Cer. Disc 91pf	
C10	150-0012	Cap. Cer. Disc .05µf	
CR1	480-1410	Diode 1N936	
CR2-4	480-1001	Diode 1N486	
Q1,2	480-5306	Transistor TN56	
Q3	480-6002	Transistor Dual NPN	
Q4	480-5805	Transistor 2N3906	
Q5	480-5301	Transistor 2N3417	
Q6,7	480-5308	Transistor 2N3405	
Q8	480-5902	Transistor RN1020	
Q9	480-5805	Transistor 2N3906	
Q10	480-5303	Transistor 2N3415	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1	470-2139	Res. 1/4W ±1% 1M M.F.	
R2	470-2130	Res. 1/4W ±1% 90.9K M.F.	
R3	470-1206	Res. ±5% 10^{10}	
R4	470-1205	Res. ±5% 10^{9}	
R5,6	470-1219	Res. 2W ±1% 10^{8}	
R7	470-1217	Res. 1/2W ±1% 10^{7}	
R8	470-1407	Res. 1/4W ±.05% 1.111×10^{6}	
R9	470-1408	Res. 1/4W ±.05% 1.111×10^{5}	
R10	470-1409	Res. 1/4W ±.05% 1.111×10^{4}	
R11	470-1410	Res. 1/4W ±.05% 1.111×10^{3}	
R12	470-1207	Res. ±5% 10^{11}	
R13	470-0014	Res. 1/4W ±5% 1.5M	
C1	150-0327	Cap. Silver Mica 2pf	
C2	150-0306	Cap. Silver Mica 15pf	
C3	150-0310	Cap. Silver Mica 150pf	
C4	150-0014	Cap. Cer. Disc .0015μf	
C5	150-0202	Cap. Mylar .015μf	
C6	150-0002	Cap. Mono. 1μf	
C7	150-0006	Cap. Mono. 1.5μf	
K1	450-0010	Relay, Reed	
	450-0601	Mounting Pin Pack	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1		Not Used	
R2,3	470-2123	Res. 1/4W ±1% 10K M.F.	
R4-6	470-2105	Res. 1/4W ±1% 9.09K	
K1-9	450-0010	Relay, Reed	
	450-0601	Mounting Pin Pack	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1-3	470-2131	Res. 1/4W ±1% 100K	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1	470-0801	Res. 1W ±10% 15K	
R2-25		Not Used	
R26,27	470-0006	Res. 1/4W ±5% 330K	
V1	570-1003	Indicator Tube NL-843	
XV1-7	570-1501	Socket	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1-5		Not Used	
R6	470-0802	Res. 1W ±10% 12K	
R7,8	470-0801	Res. 1W ±10% 15K	
R9-20		Not Used	
R21	470-1050	Res. 1/4W ±5% 47K	
R22-25	470-1030	Res. 1/4W ±5% 4.7K	
CR1	480-1505	Diode SCE-2	
CR2	480-1409	Diode 1N3789	
Q1	480-5701	Transistor Mfg. #FS19771	
A4	313-0027	Micrologic	
XV1-5		Not Used	
XV6,7	570-1501	Socket	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1	470-2130	Res. 1/4W ±1% 90.9K	
R2		Not Used	
R3	470-5325	Pot. 20K	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
R1,2		Not Used	
R3	470-1031	Res. 1/4W ±5% 4.7K	
R4	470-1015	Res. 1/4W ±5% 820	
R5		Not Used	
R6	470-0008	Res. 1/4W ±5% 82	
R7,8	470-1021	Res. 1/4W ±5% 1.5K	
R9,10	470-1037	Res. 1/4W ±5% 11K	
R11	470-2187	Res. 1/2W ±1% 750	
R12	470-1040	Res. 1/4W ±5% 15K	
R13	470-5318	Pot. Beckman #78P 100	
R14	470-2187	Res. 1/2W ±1% 750	
R15		Not Used	
R16	470-1030	Res. 1/4W ±5% 4.7K	
R17	470-1015	Res. 1/4W ±5% 820	
R18		Not Used	
R19	470-0009	Res. 1/4W ±5% 120	
R20	470-1017	Res. 1/4W ±5% 1K	
R21	470-1020	Res. 1/4W ±5% 1.3K	
R22	470-1017	Res. 1/4W ±5% 1K	
R23	470-1032	Res. 1/4W ±5% 5.6K	
R24	470-1034	Res. 1/4W ±5% 6.8K	
R25	470-2188	Res. 1/2W ±1% 301	
R26	470-5318	Pot. Beckman #78P 100	
R27	470-1034	Res. 1/4W ±5% 6.8K	
R28	470-2189	Res. 1/2W ±1% 475	
R29	470-1014	Res. 1/4W ±5% 750	
R30	470-1003	Res. 1/4W ±5% 200	
R31	470-0806	Res. 1W ±10% 150K	
C1	150-0114	Cap. Elect. 100µf 250V	
C2	150-0112	Cap. Elect. 1100µf 50V	
C3	150-0026	Cap. Cer. Disc .01µf	
C4	150-0113	Cap. Elect. 150µf 30V	
C5	150-0112	Cap. Elect. 1100µf 50V	
C6	150-0026	Cap. Cer. Disc .01µf	
C7	150-0113	Cap. Elect. 150µf 30V	
CR1-8	480-1504	Diode 1N4002	
CR9	480-1407	Diode 1N704 Zener	
CR10	480-1101	Diode 1N4148	
CR11	480-1408	Diode 1N713 Zener	
CR12-15	480-1504	Diode 1N4002	
CR16	480-1407	Diode 1N704 Zener	

TABLE 7.4 INDEX BY REFERENCE DESIGNATOR

Circuit Reference	EG&G Part No.	Description	Note
CR17	480-1101	Diode 1N4148	
CR18	480-1407	Diode 1N704 Zener	
CR19	480-1410	Diode 1N936	
Q1	480-6005	Transistor 2N4356	
Q2		Not Used	
Q3	480-6004	Transistor RCA 40324	
Q4	480-5303	Transistor 2N3415	
Q5	480-6002	Transistor Dual NPN	
Q6	480-5301	Transistor 2N3417	
Q7		Not Used	
Q8	480-6006	Transistor TQ59	
Q9	480-5805	Transistor 2N3906	
Q10	480-6002	Transistor Dual NPN	

OPTION 02

ANALOG RANGE OUTPUT

1.0 GENERAL

Option 02 provides an Analog Range Output that may be used to display the range exponent as an Analog Signal on a meter or recorder.

1.1 SPECIFICATIONS

Output Level	-	0 to +10 volts
Output Scaling (Table A)	-	1.111··· volts per decade
		10^{-11} Range = 0 volts
		10^{-2} Range = +10 volts
Accuracy	-	±1% of output ± 30mv From 5°C to 50°C

TABLE A

ANALOG RANGE OUTPUT SCALE

RANGE	NOMINAL OUTPUT	MAX. VARIATION 5°C to 50°C
10^{-11}	0	± 30mv
10^{-10}	1.111···	± 41mv
10^{-9}	2.222···	± 52mv
10^{-8}	3.333···	± 63mv
10^{-7}	4.444···	± 74mv
10^{-6}	5.555···	± 85mv
10^{-5}	6.666···	± 96mv
10^{-4}	7.777···	± 107mv
10^{-3}	8.888···	± 118mv
10^{-2}	10.0	± 129mv

Output Resistance	-	Less than 1 ohm
Maximum Loading	-	5ma (2K to Analog Common)
Protection	-	Will Withstand a short circuit to Analog Common indefinitely, independent of range.
Output Access	-	Pin 5, Accessory connector (J-3) Analog Common on Pin 8.

THEORY OF OPERATION

Natural BCD Range Exponent signals are stored in the F-R Range DCU (see Figure VI) in a standard ME-920. This code is connected to an Analog-to-Digital Converter that provides the 0 to +10 volt Analog Range Output in 1.111··· volt increments. The output is derived from an operational amplifier, providing low source resistance up to a maximum of 5ma loading (2KΩ to ground).

CALIBRATION

(Ref. Fig. A) Two adjustments are provided for Analog Output Range calibration (i.e., Zero and Full Scale).

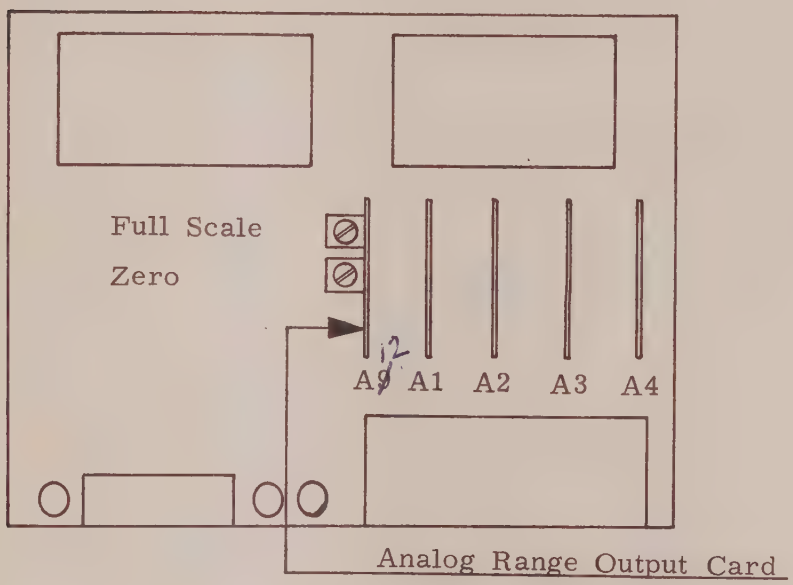


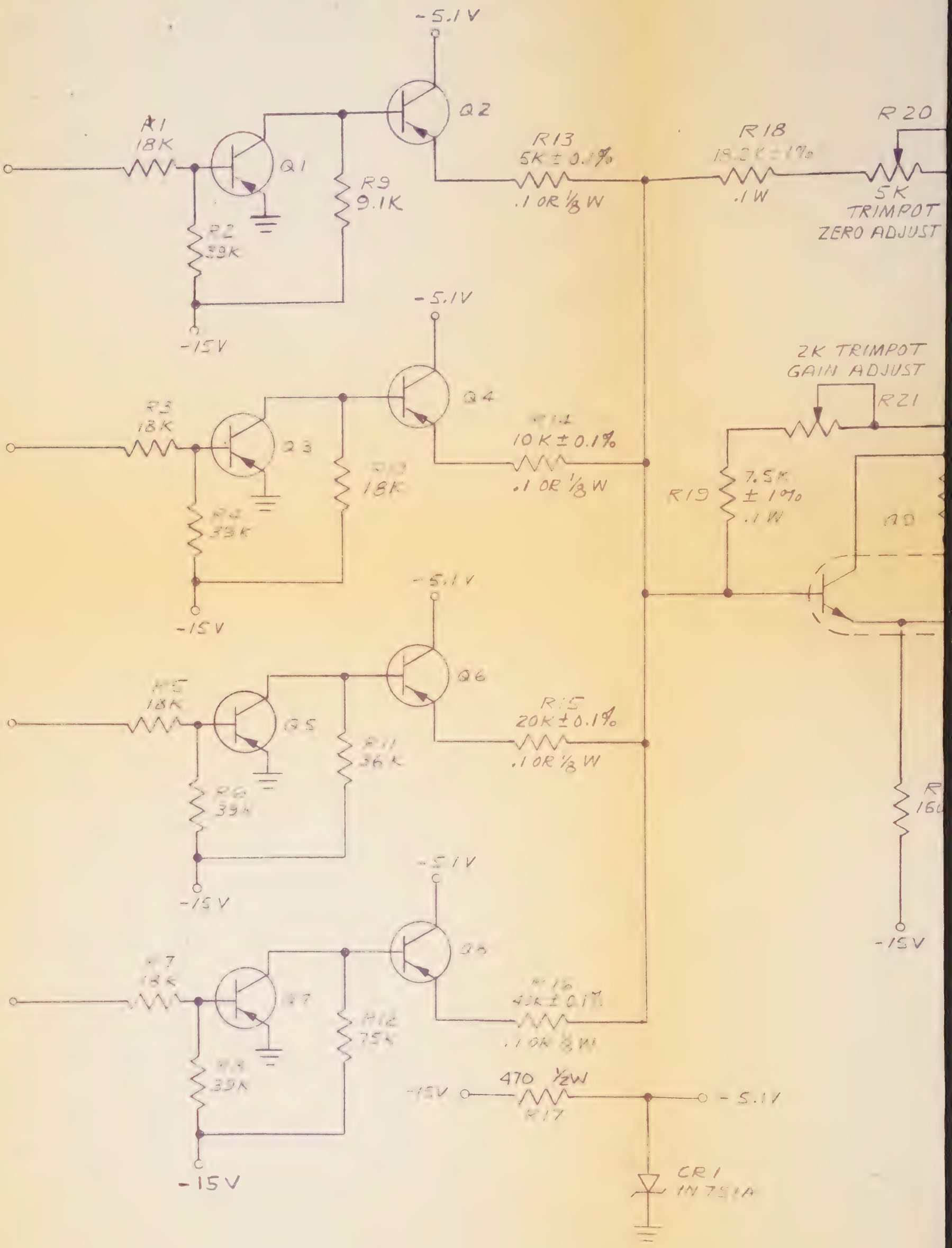
FIGURE A

EQUIPMENT REQUIRED

Digital Voltmeter, accuracy $\pm$.1%

PROCEDURE

1. Remove top cover of the ME-920-02.
2. With reference to Figure A locate the Analog Range Output card A12.
3. Connect the DVM to the Analog Range Output, Pin 5, ACCESSORY output (J-3), Common to Pin 8.
4. Push MAN front panel pushbutton.
5. Adjust instrument sensitvity with INCR pushbutton to 10^{-11} range.
6. Adjust Zero Potentionmeter on Analog Range Card to indicate zero volts $\pm$ 10mv on the DVM.
7. Adjust instrument sensitivity with DECR pushbutton to 10^{-2} range.
8. Adjust Full Scale Potentiometer on Analog Range Range Card to indicate 10.000 volts $\pm$ 10mv on DVM.
9. Adjust instrument sensitivity in one decade increments with INCR pushbutton to verify Analog Output scaling of 1.111$\cdots$ volts per decade down to zero volts $\pm$ 10mv on 10^{-11} range.
10. Loading may be applied with a 2K resistor. At full output (10^{-2} range) no load to full load output variation will be less than 10mv.



1. Q 9 TO BE FIELD SELECTED

NOTE:

CROSS INDEX	USED ON ASSY.	NO. REQ'D.
N-MXB	PC-3005	

UNLESS OTHERWISE SP

ELECTRICAL

RESISTANCE VALUES ARE IN OHMS ± 5 %
WATTS 1/4
CAPACITANCE VALUES ARE IN MFD — %
VOLTS —
DIODES ARE TYPE —
TRANSISTORS ARE TYPE 2N3638A
SYMBOLS ARE PER MIL-STD-15A

MATERIAL

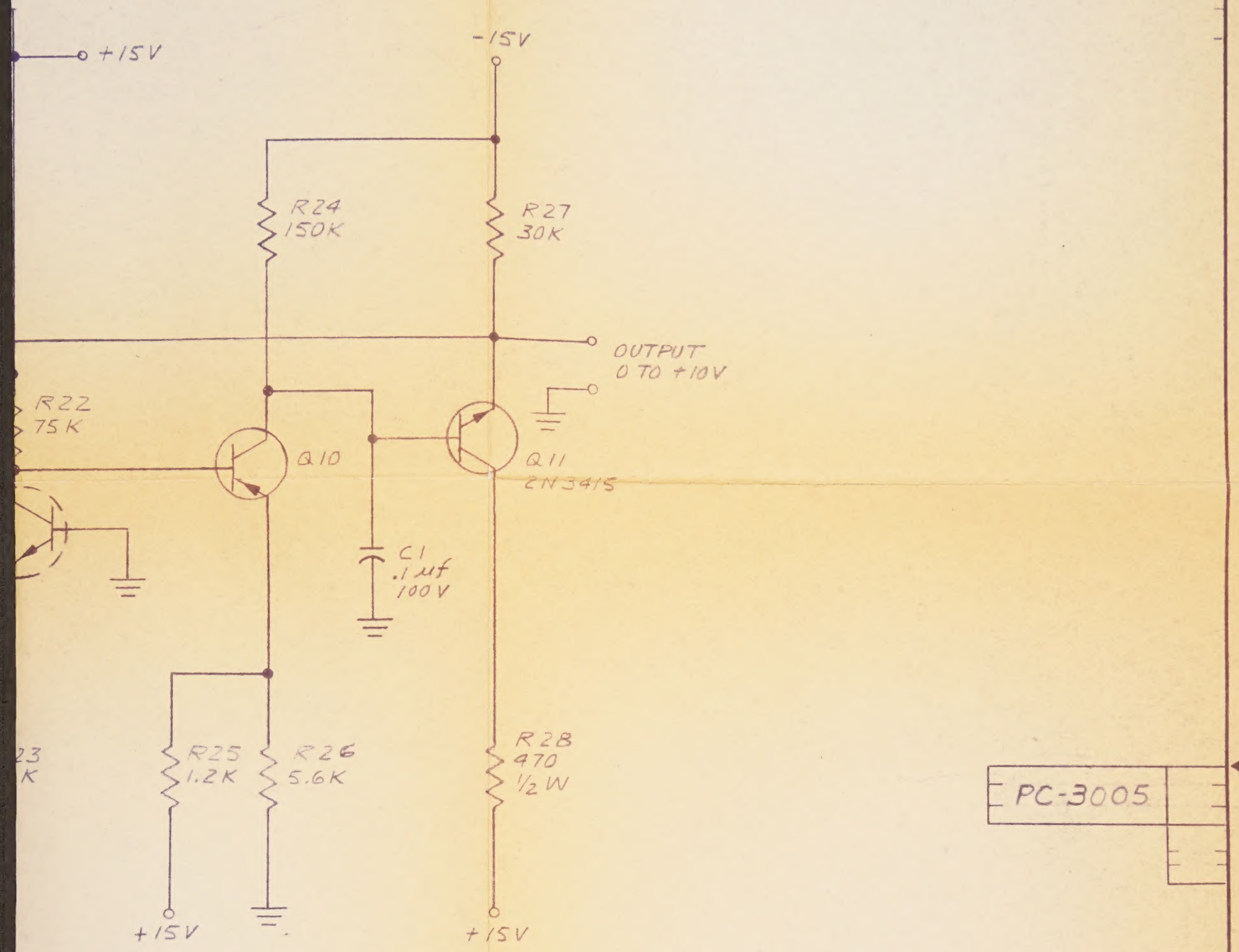
FINISH SPECS.

DO NOT SCALE THIS DRAWING

FRACT
DRILLING
MACHINI
OTHER ±
DECIMAL
NO.
L
HIGH
A. BREAK
B. ON WI
&
C. SURFA
D. 1 1/2
TO

BRUNING 40-107

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED



QTY. REQ'D.	PART NO.	DESCRIPTION	ZONE	ITEM NO.

LIST OF MATERIAL OR PART LIST

ECIFIED

ONAL DIM.	ANGULAR DIM.
LOCATION ±1/64	MACH'G. & DRILLING ±0° 15'
NG ± 1/64	
1/32	FORMED OR BENT PARTS ± 0° 30'
DIM. ± .005	THICKNESS & DIA. OF STK STD. COMM. SIZE APPLY

& LETTER SIZE DRILLED HOLES
W LIMIT — DIA. OF DRILL SPEC.
LIMIT — DIA. OF NEXT LARGER SIZE
EDGES ____ MAX.
LDS REMOVE BURRS, LOOSE SCALE SPATTER
CE ROUGHNESS PER MIL-STD-10
ITCH THREAD RELIEF WITH ROUND NOSE DL ON MACH. CUT SCREW THREADS.

DRAWN	E.H. MARTIN	3-1-66
CHECKED	WILKOSZ	3-2-66
DESIGNER		
ENGINEER	U.W. GULJE	3-2-66
PROJ. ENG.	M.R. HUFFORD	3-2-66

PROJECT APPROVAL

EDGERTON, GERMESHAUSEN & GRIER, INC.

P. O. BOX 1912 LAS VEGAS, NEVADA

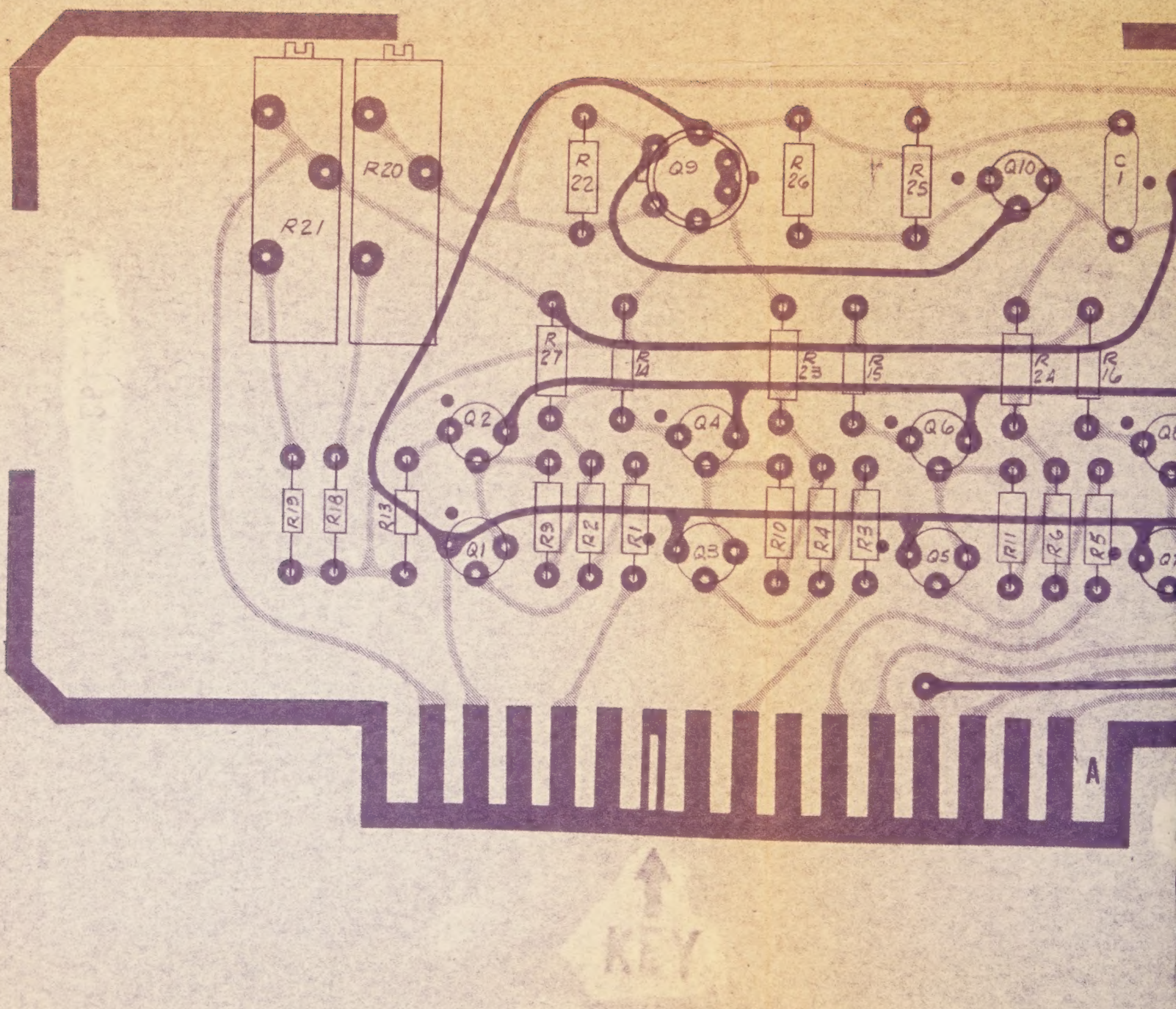
BOSTON, MASS.—LAS VEGAS, NEVADA—ALBUQUERQUE, N. M.—SANTA BARBARA, CALIF.

SCHEMATIC DIAGRAM, D/A CONVERTER-4 BIT

CODE OR IDENT NO.	SIZE	
99626	C	PC-3005

SCALE NONE

SHEET 1 OF 2



NOTES:

1. ALL HOLES .040 .045 DIA AFTER PLATING
2. FOR SCHE. DIA. SEE PC-3005 1 OF 2
3. FOR PRINTED CIRCUIT BD. SEE PB-105
4. ALL 1/4 DIA. PADS ARE TO HAVE .060 DIA. HOLES THRU AFTER PLATING. 6 HOLES

N-ME9

CROSS INDEX | USED ON ASSY. | NO. REQ'D.

UNLESS OTHERWISE

ELECTRICAL

RESISTANCE VALUES ARE IN OHMS ____ %
WATTS ____
CAPACITANCE VALUES ARE IN MFD ____ %
VOLTS ____
DIODES ARE TYPE ____
TRANSISTORS ARE TYPE ____
SYMBOLS ARE PER MIL-STD-15A

FRAC
DRILLI
MACHI
OTHER
DECIMA

MATERIAL

NO.
HIGH

FINISH SPECS.

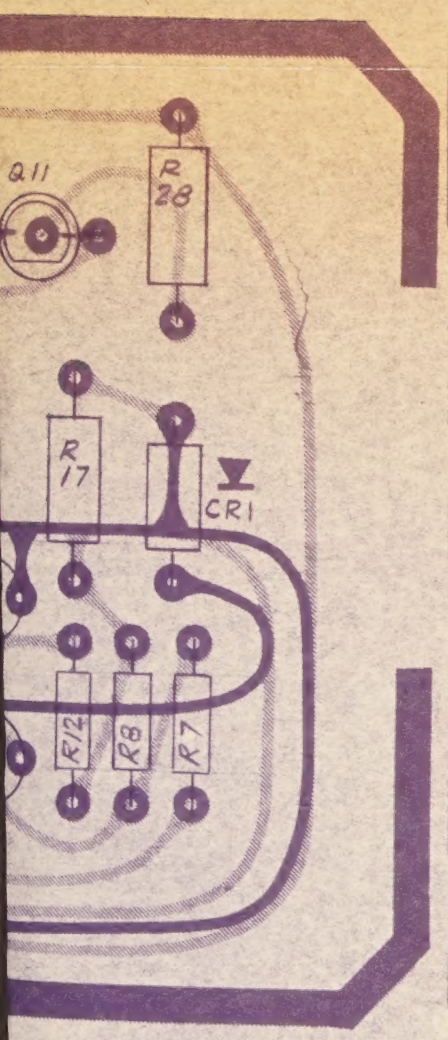
A. BRE
B. ON
&
C. SUR
D. 1 1/

DO NOT SCALE THIS DRAWING

BRUNING 40-107

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED
/	/	SEE SHT 1	/	/

STOCK NO.	REF. DES.	QTY	VALUE OR TYPE	DESCRIPTION
470-1042	R1,3,5,7,10	5	18K	RES. 1/4W ±5%
470-1049	R2,4,6,8	4	39K	
470-0045	R9	1	9.1K	
470-1048	R11	1	36K	
470-1053	R12, 22	2	75K	
470-0052	R23	1	160K	
470-1057	R24	1	150K	
470-1019	R25	1	1.2K	
470-1032	R26	1	5.6K	
470-1046	R27	1	30K	



470-2311	R13	1	4.99K	RES. 1/4W .1% SELECTED
470-2013	R14	1	40.2K	
470-2123	R15	1	10K	
470-2126	R16	1	20K	
470-2125	R18	1	18.2K	RES. 1/4W ±1%
470-2122	R19	1	7.5K	
470-0407	R17,28	2	470	RES. 1/2W ±5%
				PC-3005
470-5305	R20	1	5K	POT BOURNS
470-5306	R21	1	2K	
150-0005	C1	1	.1 μF 100V	CAP. CER. DISC.
	CR1	1	IN751A	DIODE
480-5802	Q1,2,3,4,5,6,7,8,10	9	2N3638A	TRANSISTOR
480-6002	Q9	1	DUAL NPN	
480-5303	Q11	1	2N3415	

QTY. REQ'D.	PART NO.	DESCRIPTION	ZONE	ITEM NO.
1	250-0012	PB-105		1

LIST OF MATERIAL OR PART LIST

SPECIFIED

TIONAL DIM.	ANGULAR DIM.
G LOCATION ±1/64	MACH'G. & DRILLING ±0° 15'
NG ± 1/64	
± 1/32	FORMED OR BENT PARTS ± 0° 30'
DIM. ± .005	THICKNESS & DIA. OF STK STD. COMM. SIZE APPLY.

& LETTER SIZE DRILLED HOLES
OW LIMIT — DIA. OF DRILL SPEC.
LIMIT — DIA. OF NEXT LARGER SIZE
K EDGES _____ MAX.
ELDS REMOVE BURRS, LOOSE SCALE SPATTER
ACE ROUGHNESS PER MIL-STD-10
PITCH THREAD RELIEF WITH ROUND NOSE OL ON MACH. CUT SCREW THREADS.

DRAWN	L.DANGELO	7-11-66
CHECKED	JB	4-1
DESIGNER		4
ENGINEER	AWG	4-1
PROJ. ENG.	MRH	4-1

PROJECT APPROVAL

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P. O. BOX 1912 LAS VEGAS, NEVADA
BOSTON, MASS.—LAS VEGAS, NEVADA—ALBUQUERQUE, N. M.—SANTA BARBARA, CALIF.

ASSY. DWG.
D/A CONVERTER - 4 BIT

CODE OR IDENT NO.	SIZE	
99626	C	PC-3005

SCALE 2:1 SHEET 2 OF 2

EG&G

MP MASTER
MA28899